BEPAC

July 1990

Technical Note 90/2

Standard dwellings for modelling: details of dimensions, construction and occupancy schedules

E A Allen and A A Pinney

Building Research Establishment

Building Environmental Performance Analysis Club

Further information on BEPAC publications
can be obtained from:

BRE Bookshop
Building Research Establishment
Garston Watford WD2 7JR

Telephone 0923 664444

ABOUT BEPAC

The Building Environmental Performance Analysis Club (BEPAC) was formed in late 1987 to provide a forum for all concerned with the prediction of environmental conditions in building, especially those interested in the application and development of computer-based methods. Its members include consulting architects and engineers, computer systems developers, government agencies and researchers from the public sector, utilities and universities. BEPAC has a wide scope, embracing thermal, visual and acoustical environmental design, with a particular interest in sharing data, methods and experience within and between these fields.

BEPAC brings its work to its members and to industry and the professions generally, through publications, meetings and workshops, and has established a number of Task Groups for detailed study of particular issues. Publications will include both **Technical Notes**, written by members on subjects of topical interest, and **BEPAC Reports**, containing recommended data sets, guidance, procedures, etc, agreed by its Task Groups and the BEPAC Committee. BEPAC also aims to represent the interests of its members on other bodies concerned with research and standardisation in the field of environmental performance.

While all currently-planned activities will be in the United Kingdom, BEPAC welcomes members from other countries. Enquiries about membership should be addressed to:

The Secretary, BEPAC
Environmental Systems Division
Building Research Establisment
Garston
Watford
WD2 7JR

Telephone: 0923 664132 or 0923 664487 (direct dial)
Telephone: 0923 894040 (switchboard)
Telex: 923220 (BRSBRE)G
Fax: 0923 664010

(outside the United Kingdom, the dialling code is +44 923)

First published 1990

BEPAC TN 90/4
ISBN 0 187 212 605 7

Price £6 to BEPAC members
£12 to non-members

DEPARTMENT OF THE ENVIRONMENT

BUILDING RESEARCH ESTABLISHMENT

BEPAC RESEARCH REPORT

A SET OF STANDARD DWELLINGS - DETAILS OF DIMENSIONS, CONSTRUCTION AND OCCUPANCY SCHEDULES

Elizabeth J. Allen & Adam A. Pinney

SUMMARY

A set of 'standard' dwellings, comprising a Detached House, a Semi-Detached House, a Bungalow, a Post-1919 Terrace, a Period Terrace and a Timber-Framed House is defined. The set can be seen to serve three main functions:

1) As a series of 'benchmark' buildings for which the predictions of different thermal prediction models could be tested.

2) As a series of example houses which, while they do fully cover all house types currently existing in the UK, are based on 'averages' of several types.

3) As an example of the level of detail needed to describe a building such that it can be modelled without the need for the modeller to make many assumptions.

The dimensions, construction and thermo-physical properties of each house are given, together with casual gain information corresponding to two occupancy schedules. These may be considered as 'guide' values such that subsequent thermal modelling of the dwellings is possible and, while efforts have been made to make the information as representative as possible, should not be taken to be fully realistic. The design heat loss and radiator sizing for each house are also determined.

The descriptions should be sufficient for modelling by most currently-available thermal models, and therefore represent a 'reference' set of building types, against which different models can be tested, and on which the effects of changing a design parameter (for example window area) can be tested.

November 1989

Building Research Establishment
Building Research Station
Garston, Watford, WD2 7JR
Tel: 0923 894040

CONTENTS

1 INTRODUCTION

In order for the thermal behaviour of buildings to be modelled accurately, it is necessary to have detailed knowledge of their design and use. The dimensions and construction of a set of six 'standard' dwellings (detached, semi-detached, bungalow, post-1919 terrace, period terrace and timber-framed) are defined, together with casual gain information corresponding to occupancy schedules. This set of buildings can be used as 'benchmarks' against which a thermal prediction model or technique can be tested, and the data given should provide sufficient detail to allow the buildings to be modelled using most currently-available models or techniques. The set of dwellings does not fully cover all house types in the UK, but nonetheless is typical of many houses and, while attempts have been made to ensure all data given are as representative as possible, they should not be taken to be 'absolute' values.

This report presents the buildings in what could be called a 'basic configuration', that is to say with a single set of dimensions, material properties, occupancy levels, etc. However, it is possible to use these data as the basis for design parameter tests, whereby a particular parameter, for example window properties, are varied, and the results compared with those from the basic configuration. In this way the effects of any design change can be assessed, and optimised.

We have attempted to give sufficient information in the report so that a model user need not make any assumptions, and it more than one modeller exactly follows the guidance given here, they will be modelling the dwellings in the same way. However, some information given may not be the same as the current practice of some modellers (for example, we suggest using a fixed ground temperature); such information may, of course, be changed by a particular user, but it is necessary to bear in mind that such changes must be noted if the objective is to compare results with those from other modellers or other models.

We do not, in this report, suggest how any particular model or method is used, but we do provide sufficient information for some of the more detailed models to be used in more than one way. For example, some models calculate convection tranfer coefficients at each simulation time step as a function of wind speed, wind direction, etc, whereas other models use a fixed value, which we present here. If an inter-model comparison exercise is being performed, we suggest each model be used in its most normal way (in this example allowing the model to calculate its own heat transfer coefficients) in the first instance, then if the aim is to make each model as similar as possible, simulations could be run using the suggested fixed coefficients in all models, if the models allow.

With the exception of the timber-framed house, the standard dwellings are based on the house types derived for the Department of Energy's 'Home Heating Cost' project (Finbow, National Building Agency, private communication). Each of the six sets of data is considered representative of its own particular type of built-form within the U.K. housing stock. The occupancy schedules detailed correspond to those used in previous BRE modelling work (Bloomfield 1988, private communication).

2 SELECTION OF HOUSE TYPES

2.1 Breakdown of the U.K. housing stock

Table 1 below gives the National Building Agency (NBA) breakdown of the 1981 U.K. housing stock by house type, age, ownership and the existence of central heating (Finbow NBA, private communication). The breakdown by age is based on the National Dwelling and House Survey (NDHS) statistics; and the breakdown by house type and the existence of central heating is from Audits of Great Britain (AGB) data. The statistics are for occupied dwellings (4.2% less than the total number of dwellings).

Table 2 gives the breakdown by type of built form of solid/cavity external wall, single/double glazing and loft insulation. Statistics are AGB estimates of December 1979 (Leach 1981).

House type	Total number of occupied dwellings	Ownership		Central heating	No central heating
		Private sector	Public sector		
Detached	2533	2280	253	2141	392
Semi-detached	6455			3494	2961
Pre-1919	678			201	477
Post-1919	5777	3325	2452	3293	2484
Bungalow	1596	1117	479	1238	358
Post-1919 terrace	3656	1970	1686	2084	1572
Mid-terrace	2340	1261	1079	1334	1006
End-terrace	1316	709	607	750	566
Pre-1919 terrace	2745	1477	1268	815	1930
Mid-terrace	1757			522	1235
End-terrace	988			293	695
Flats	3157	504	2653	1821	1336
Purpose-built	2278	282	1996	1314	964
2 ext. walls	948			547	401
2 ext. walls + roof	510			294	216
3 ext. walls	533			307	226
3 ext. walls + roof	287			166	121
Converted	879	222	657	507	372

TABLE 1: Breakdown of the 1981 U.K. housing stock by ownership and the existence of central heating (all values thousands)

		House Type					
		Detached	Semi-detached	Bungalow	Post-1919 terrace	Pre-1919 terrace	Flats
Total		2558	6515	1613	3325	2606	3057
EXTERNAL WALL	Cavity	1552	3517	993	1627	832	1286
EXTERNAL WALL	No cavity	998	2981	617	1682	1764	1739
EXTERNAL WALL	Unknown	8	16	4	17	11	31
EXTERNAL WALL	Insulated cavity	286	304	170	147	28	87
EXTERNAL WALL	Un-insul. cavity	1258	3210	819	1477	803	1184
EXTERNAL WALL	Unknown	8	3	3	1	0	15
Double glazing		978	1169	478	266	151	289
Access to loft		2341	6037	1442	2916	1805	676
Loft insulated		1887	4049	1209	1828	759	386

TABLE 2 Breakdown of the U.K. housing stock by external wall construction, glazing and loft insulation (all values thousands)

Table 3 gives the number of timber-framed housing completions over recent years. The figures are estimates by the Timber Research and Development Association (Leach 1981).

Year	No. of completions	% of all completions
1974	23 225	8.3
1975	37 631	11.7
1976	47 041	14.5
1977	48 004	15.0
1978	43 214	15.0
1979	39 000	16.1

TABLE 3 Timber-framed housing completions

2.2 House types

For the sake of consistency it was considered sensible to adopt the same standard house types as those devised by the NBA for the Department of Energy's 'Compare Your Home Heating Cost' project (Finbow NBA, private communication). In view of the increasing number of timber-framed houses, an example of such was provided by a private sector developer for inclusion. The set of standard dwellings therefore comprises:

Detached house

Semi-detached house

Bungalow

Post-1919 terrace

Period terrace

Timber-framed house

(The NBA holds on file examples of a typical large detached house and typical 1 and 2 bedroom flats)

Because the 'Compare Your Home Heating Costs' booklet is primarily addressed to the owner-occupier, the standard dwellings chosen by the NBA are essentially those typical of the private sector. It is felt (Finbow NBA, private communication) that as the buildings are, in general, existing they would not normally have high levels of insulation other than in the loft (for which grants are available).

2.2a DETACHED HOUSE

There is a wide variation in the size and shape of detached houses. The example chosen by the NBA has a floor area equal to the average of all those detached houses in the English House Condition Survey (EHCS) 1981 and those on the records of the Nationwide Building Society. The plans are based on those offered by a private sector developer. The house has uninsulated cavity walls and solid ground floor, single glazing and loft insulation.

2.2b SEMI-DETACHED HOUSE

Analysis of the EHCS data showed little variation in the floor area and dimensions of semi-detached houses with age. The plans are based on a typical post-1919 house type. The house has uninsulated cavity walls, solid ground floor, single glazing and loft insulation.

2.2c BUNGALOW

The example bungalow chosen by NBA has a floor area equal to the average of all those on the records of the Nationwide Building Society, and the plans are from a private sector developer. The bungalow has uninsulated cavity walls, solid ground floor, single glazing and loft insulation.

2.2d POST-1919 TERRACE

The average depth and frontage measurements from analysis of the EHCS data were adopted by the NBA for the standard post-1919 terrace dwelling. The house has uninsulated cavity walls, solid ground floor, single glazing and loft insulation.

2.2e PERIOD TERRACE

The NBA selected a typical plan for a period terrace house, which included a rear extension. For the main terrace the average depth and frontage measurements were obtained from analysis of the EHCS data. The total floor area (ie including rear addition) corresponds roughly with the Nationwide Building Society figure for this type of dwelling. The house has solid brick walls, single glazing and loft insulation. The main terrace has a suspended timber ground floor and the rear extension a solid ground floor.

2.2f TIMBER-FRAMED HOUSE

The plans and construction details of a typical timber-framed terraced house were supplied by a private sector developer. The house has single glazing and loft insulation.

3 CONSTRUCTION AND THERMAL PROPERTIES OF BUILDING ELEMENTS

3.1 Construction of building elements

The construction of the major building elements for each dwelling are as follows ('inside' to 'outside'):

3.1a EXTERNAL WALLS

(a) Cavity (detached, semi-detached, bungalow, post-1919 terrace)

0.016 m Plaster (medium density)
0.105 m Brick (inner leaf)
0.065 m Cavity
0.105 m Brick (outer leaf)

(b) Solid (period terrace)

0.016 m Plaster (madium density)
0.220 m Brick (outer leaf)

(c) Timber frame

0.012 m Plasterboard
0.060 m Glass fibre quilt (94%) and pine studs (6%)
0.029 m Cavity
0.009 m Plywood
0.050 m Cavity
0.105 m Brick (outer leaf)

3.1b PARTY WALLS

(a) Brick (all dwellings except timber-framed)

0.016 m Plaster (medium density)
0.105 m Brick (inner leaf)
0.016 m Plaster (medium density)

(b) Timber frame

0.012 m Plasterboard
0.089 m Cavity
0.060 m Glass fibre quilt
0.139 m Cavity
0.032 m Plasterboard

3.1c INTERNAL WALLS

(a) Brick (all dwellings except timber-framed)

As for brick party wall

(b) Timber frame

0.012 m Plasterboard
0.089 m Cavity
0.012 m Plasterboard

3.1d INTERNAL FLOORS (ALL DWELLINGS)

(0.005 m Carpet) - NBA considers all floors uncarpeted
0.020 m Timber
0.200 m Cavity
0.010 m Plasterboard

3.1e ROOF (ALL DWELLINGS)

0.010 m Plasterboard
0.100 m Glass fibre quilt
Loft space
0.010 m Roofing tiles

3.2 Thermal properties of building elements

Material	Density kg/m^3	Thermal Conductivity W/m K	Specific Heat Capacity J/kg K
Brick (inner leaf)	1700	0.62	800
Brick (outer leaf)	1700	0.84	800
Carpets	160	0.06	1000
Concrete (dense)	2100	1.40	840
Earth	1900	1.40	1700
Glass fibre quilt	250	0.04	840
Pine	650	0.14	1420
Plaster (medium density)	800	0.26	1000
Plasterboard	950	0.16	840
Plywood	530	0.14	900
Roofing tiles	1900	0.84	800
Softwood	230	0.12	2760
Timber flooring	650	0.14	1200
Glass (clear float)	2500	1.05	750

TABLE 4 Thermal properties of individual building elements (CIBS 1980)

Material	Surface Emissivity	Surface Absorptivity
Brick (inner leaf)	0.93	0.70
Brick (outer leaf)	0.90	0.93
Carpets	0.90	0.65
Concrete (dense)	0.90	0.65
Earth	0.90	0.85
Glass fibre quilt	0.90	0.30
Pine	0.90	0.65
Plaster (medium density)	0.91	0.50
Plasterboard	0.91	0.50
Plywood	0.90	0.65
Roofing tiles	0.90	0.60
Softwood	0.90	0.65
Timber flooring	0.91	0.65
Glass (clear float)	0.90	0.20

TABLE 5 Surface emissivities and absorptivity (Clarke 1985)

The surface resistances given below allow for convective and radiative heat flow from the surface. They are calculated by

$$Rs = 1/(\epsilon\, hr + hc)$$

where hr = radiation coefficient (W/m^2K), hc = convection coefficient (W/m^2K) and ϵ = emissivity.

CIBS (1980) suggest values for hr and hc for different surfaces, and these are used to split the surface resistances into their component parts. Values in the following table are for 'normal' building exposures. These values should only be used in those models that require them: models which calculate the convective coefficient, and have more detailed treatment of radiation transfer, should be used in the latter ways.

	Resistance m^2K/W	Radiation coefficient W/m^2K	Convection coefficient W/m^2K
External walls	Rso = 0.05 Rsi = 0.12 Ra = 0.18	5.7 5.7 4.6	14.0 3.0 1.4
Internal walls	Rso = 0.12 Rsi = 0.12 Ra = 0.18	5.7 5.7 4.6	3.0 3.0 1.4
Roofs (pitched)	Rso = 0.04 Rsi = 0.11 Ra = 0.18	5.7 5.7 4.6	18.1 4.3 1.4
Internal floors	Rso = 0.12 Rsi = 0.12 Ra = 0.18	5.7 5.7 4.6	3.0 3.0 1.4

TABLE 6 Outside surface (Rso), inside surface (Rsi) and air gap (Ra) resistances (CIBS 1980)

3.2a GROUND FLOORS

The U-value of the ground floor of the dwellings (considered to be un-carpeted by the NBA) are taken from the CIBS Guide A3 (1980), table A3.10, and are as follows:

Detached house, based on the 10m x 6m solid ground floor with 4 exposed edges

$U = 0.74\ W/m^2K$

Semi-detached house, as detached house (assuming a pair of houses)

$U = 0.74\ W/m^2K$

Bungalow, as detached house

$U = 0.74\ W/m^2K$

Post-1919 terrace and timber-framed house

Mid terrace, based on a very long solid ground floor, 6m deep with 4 exposed edges

$U = 0.55\ W/m^2K$

End terrace, assumed to be equivalent to the semi-detached

$U = 0.74\ W/m^2K$

Period terrace

Main terrace, based on a very long suspended ground floor, 6m deep

$U = 0.60\ W/m^2K$

Rear extension:

End terrace (hall party) or mid terrace, based on a 4m x 2m solid ground floor with 2 perpendicular exposed edges

$U = 0.95\ W/m^2K$

End terrace (living room party), table A3.10 does not account for floors with 3 exposed edges, so this is based on the mean between 4 edges exposed and 2 edges exposed (4m x 2m solid)

$U = 1.24\ W/m^2K$

In order for ground floor descriptions to be input to certain thermal simulation computer programs, it is suggested that a layer of earth is included below the floor; the thickness of this layer is altered to give the required U-value (see Tables 7 to 10).

Dwelling Type	U-Value W/m^2k	Thickness of earth (m)	Decrement Factor		Admittance		Surface Factor	
			Magnitude	Phase + lead hrs, - lag	Magnitude w/m^2k	Phase + lead hrs, - lag	Magnitude	Phase + lead hrs, - lag
Period terrace, rear extension (hall party and mid)			0.010	- 0.9	5.421	+ 1.1	0.423	- 1.8
Period terrace, rear extension (living-room party)	0.95	1.18	0.001	- 10.4	5.421	+ 1.1	0.423	- 1.8
Detached Semi-detached Bungalow Post-1919 terrace (end) Timber-framed (end)	0.74	1.60	0.000	- 21.9	5.421	+ 1.1	0.423	- 1.8
Post-1919 terrace (mid) Timber-framed (mid)	0.55	2.25	0.000	- 15.8	5.421	+ 1.1	0.423	- 1.8

Solid ground floors
Uncarpeted

0.1 m concrete

TABLE 7 Solid ground floors, uncarpeted

Dwelling Type	U-Value w/m²k	Thickness of earth (m)	Decrement Factor		Admittance		Surface Factor	
			Magnitude	Phase + lead hrs, - lag	Magnitude w/m²k	Phase + lead hrs, - lag	Magnitude	Phase + lead hrs, - lag
Period terrace, rear extension (hall party and mid)	1.114	0.84	0.007	- 1.3	3.675	+ 0.8	0.575	- 0.6
Period terrace, rear extension (living-room party)	0.874	1.18	0.001	- 10.8	3.675	+ 0.8	0.575	- 0.6
Detached Semi-detached Bungalow	0.693	1.60	0.000	- 22.3	3.675	+ 0.8	0.575	- 0.6
Post-1919 terrace (end) Timber-framed (end)	0.55	2.25	0.000	- 15.8	5.421	+ 1.1	0.423	- 1.8
Post-1919 terrace (mid) Timber-framed (mid)	0.524	2.25	0.000	- 16.3	3.675	+ 0.8	0.575	- 0.6

Solid ground floors
Carpeted

The U-value of a carpeted ground floor is calculated by adding the thermal resistance of the layer of carpet to the thermal resistance of the floor and taking the **reciprocal** (CIBS 1980)

0.005 m carpet
0.1 m concrete

TABLE 8 Solid ground floors, carpeted

Dwelling Type	U-Value w/m²k	Thickness of earth (m)	Decrement Factor		Admittance		Surface Factor	
			Magnitude	Phase + lead hrs, - lag	Magnitude w/m²k	Phase + lead hrs, - lag	Magnitude	Phase + lead hrs, - lag
Period terrace (main part)	0.60	1.57	0.000	- 22.6	2.312	+ 1.6	0.754	- 0.6

Suspended ground floor
Uncarpeted

0.02 m timber flooring
cavity
0.1 m concrete

TABLE 9 Suspended ground floor, uncarpeted

Dwelling Type	U-value w/m²k	Thickness of earth (m)	Magnitude	Phase + lead hrs, - lag	Magnitude w/m²k	Phase + lead hrs, - lag	Magnitude	Phase + lead hrs, - lag
Period terrace (main part)	0.568	1.57	0.000	- 22.5	1.794	+ 1.1	0.795	- 0.3

Suspended ground floor
Carpeted

0.005 m carpet
0.02 m timber flooring
cavity
0.1 m concrete

TABLE 10 Suspended ground floor, carpeted

3.2b WINDOWS AND DOORS

All windows (except 'French' windows) are assumed to be timber-framed casement or sash windows, with 30% of the overall area as timber ($U = 1.3\ W/m^2K$) and single glazed (glazing $U = 5.6\ W/m^2K$). The corresponding U-value for the whole window is $4.3\ W/m^2K$.

Front doors are assumed to have a 'window' occupying one third of the door area (this 'window' does not have a separate frame). The U-value of both solid timber and hollow core door material is $2.5\ W/m^2K$. The average U-value for the door is therefore $3.0\ W/m^2K$. All doors (except 'French' windows) have a wooden frame ($U = 1.3\ W/m^2K$) around the three upper edges, 0.050m wide. 'French' windows are assumed to have no frame.

All other doors (eg back door, 'French' windows) are assumed to be fully glazed and to have the same U-value as single glazed windows (ie $4.3\ W/m^2K$). Internal doors are not explicitly modelled; and the door area is treated as an internal wall.

For more detailed modelling, frames and doors can be considered as being composed of 0.070m and 0.030m thicknesses of softwood respectively (see also section 4). In some models the total window frame and door frame areas of each surface are lumped together and treated as mullions in a separate part of the wall surface. Glazing is 0.006m clear float with direct transmittance 0.80 and total heat gain factor 0.84 (at normal incidence), or more specifically, at five angles of incidence, transmittance and heat gain factors (Clarke 1984) are:

Angle of incidence	Direct transmission	Solar heat gain
0.0	0.78	0.82
40.0	0.76	0.81
55.0	0.72	0.77
70.0	0.58	0.64
80.0	0.35	0.40

TABLE 11 Transmission and solar heat gain of 6mm single glazing

Other properties of the glazing are:

Conductivity	= 1.05 W/m K	Density	= 2500 kg/m^3
Specific heat	= 750 J/kg K	Absorptivity	= 0.20
Emissivity	= 0.90	Refractive index	= 1.526
Extinction coefficient	= 0.0197 mm^{-1}		

It is assumed in all cases that there is no self-shading by the window reveal, and the effect of the set-back of the window on the internal volume of the building is ignored. For thermal models which do not permit accurate analysis of internal short wave radiation coming through windows, the floor of each zone should be taken as the plane on which all solar radiation falls.

3.3 Derived thermal properties of building structures

The U-value, decrement factor, admittance and surface factor (shown in table 13 overleaf) were determined for each construction using the program described by Bloomfield (1984).

3.4 Response factors

A convenient way of expressing the overall thermal performance of a building is by a ratio known as the response factor fr (CIBS 1980), calculated by

$$fr = [\sum(AY) + nV/3]/[\sum(AU) + nV/3]$$

where $\sum(AY)$ = area weighted sum of the admittances of all surfaces exposed to the heated space (including both sides of internal partitions)

$\sum(AU)$ = area weighted sum of the U-values (refers only to area of the building envelope through which heat flow occurs)

n = infiltration rate (air changes per hour)

and V = volume of enclosed space

(A thermally lightweight building will have a response factor of about 2.5, and a heavyweight building a response factor of about 6.0)

The response factors for each dwelling (assuming an air infiltration rate of 1 ach throughout the house, and no heat flow through internal partitions) are given in table 12.

House type	Response Factor	
	Uncarpeted floors	Carpeted floors
Detached	4.0	3.8
Semi-detached	4.4	4.2
Bungalow	4.4	4.1
Post-1919 Terrace Mid	5.8	5.5
Living room party	4.8	4.6
Hall party	4.7	4.4
Period Terrace Mid	4.8	4.7
Living room party	3.7	3.6
Hall party	3.8	3.7
Timber-framed Mid	3.3	3.0
Hall party	2.8	2.6
Kitchen party	2.8	2.6

TABLE 12 Response factors

Construction	U-Value w/m^2k	Decrement Factor		Admittance		Surface Factor	
		Magnitude	Phase + lead hrs, - lag	Magnitude w/m^2k	Phase + lead hrs, - lag	Magnitude	Phase + lead hrs, - lag
External wall (cavity)	1.397	0.411	- 7.9	3.810	+ 1.6	0.608	- 1.2
External wall (solid)	1.986	0.470	- 6.6	3.892	+ 1.3	0.580	- 1.0
External wall (timber frame)	0.499	0.658	- 5.0	0.916	+ 3.2	0.930	- 0.3
Party/internal wall (brick)	1.878	0.631	- 4.6	3.928	+ 2.7	0.713	- 1.7
Party wall (timber frame)	0.400	0.904	- 2.8	1.767	+ 4.7	0.951	- 0.8
Internal wall (timber frame)	1.754	0.994	- 0.6	0.693	+ 5.6	0.995	- 0.3
Internal floor (uncarpeted)	1.550	0.988	- 0.8	0.924	+ 5.5	0.990	- 0.4
Internal floor (carpeted)	1.358	0.981	- 1.0	0.848	+ 5.3	0.986	- 0.4
Internal ceiling (uncarpeted)	1.550	0.988	- 0.8	0.773	+ 5.5	0.992	- 0.4
Internal ceiling (carpeted)	1.358	0.981	- 1.0	0.894	+ 5.4	0.988	- 0.4
Roof	0.345	0.997	- 0.6	0.671	+ 3.7	0.963	- 0.2

TABLE 13 Derived thermal properties of building structures

4 PLANS AND ELEVATIONS

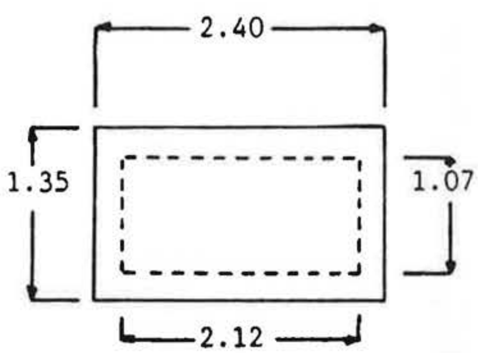
All dwellings are assumed to be at latitude 51°N, longitude 1°W (Kew, London). Ground reflectivity is taken to be constant throughout the year at 0.2, and ground temperature is also taken as constant at 10°C throughout the year (this is a recommendation to ensure comparability between different models; modellers may chose time varying values as being more representative if necessary).

The plans and elevations of the standard dwellings follow. All dimensions shown are internal, although some (for example the height above the ground of upstairs windows) include the thickness of internal partitions. All dimensions are in metres, and the scales used for some plans are approximate only. For windows two areas are shown: area A (shown by a dashed line) represents the glazing area, while area A' (a solid line) represents glazing plus frame area. Similarly doors with door frames are shown by dotted lines (the door itself) and the door plus frame (solid lines).

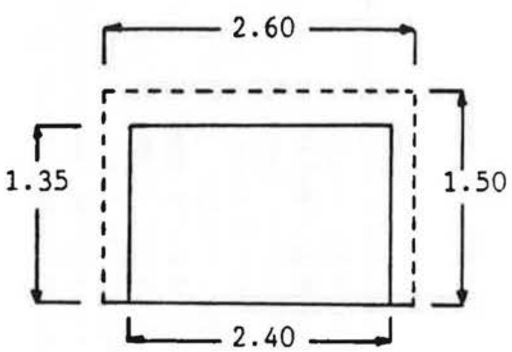
In some instances it may be necessary to account for the fact that the wall cavity is closed around window and door reveals, giving additional heat losses. This can be modelled in two ways: 1) by increasing the window and door frame dimensions (or for French windows by adding a frame) by 100mm on either side and 150mm at the lintel (see example below), 2) using a separate 'surface' having the properties and thickness of brick, in the same way that frames can be lumped together and treated as a surface. The glazed area does not change in either case. Care should be taken in those models which require the sum of net wall area, glazing, doors and frames to be the same as the total gross wall area.

In the following figures, the window and door areas are those of the original plans (ie not accounting for closed cavities). The areas shown can be enlarged, if required, by following the rules given above. All chimney breasts have been omitted from the figures, as in the original specifications they were given the same U-value as the walls they were in.

In the design heat loss calculations (section 5) the increased window and door dimensions have been used to represent the closed cavities around the windows.



Actual window:
Glazed area = 2.27 m²
Opening area = 3.24 m²
Frame area = 0.97 m²



Modified window:
Original opening area = 3.24 m²
Modified opening area = 3.90 m²
Modified frame area = 1.63 m²

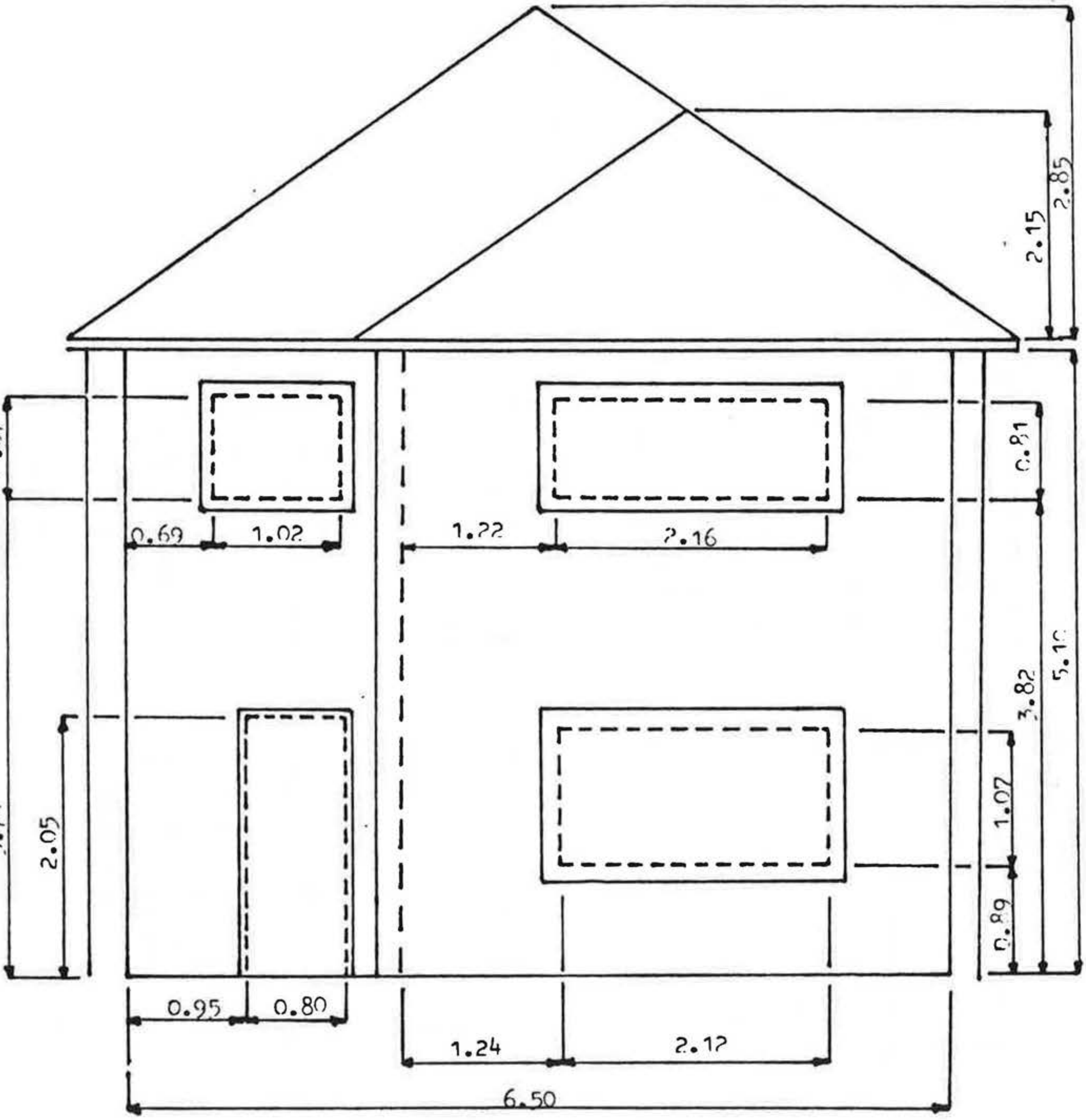


FIGURE 1 Detached house elevation (front)

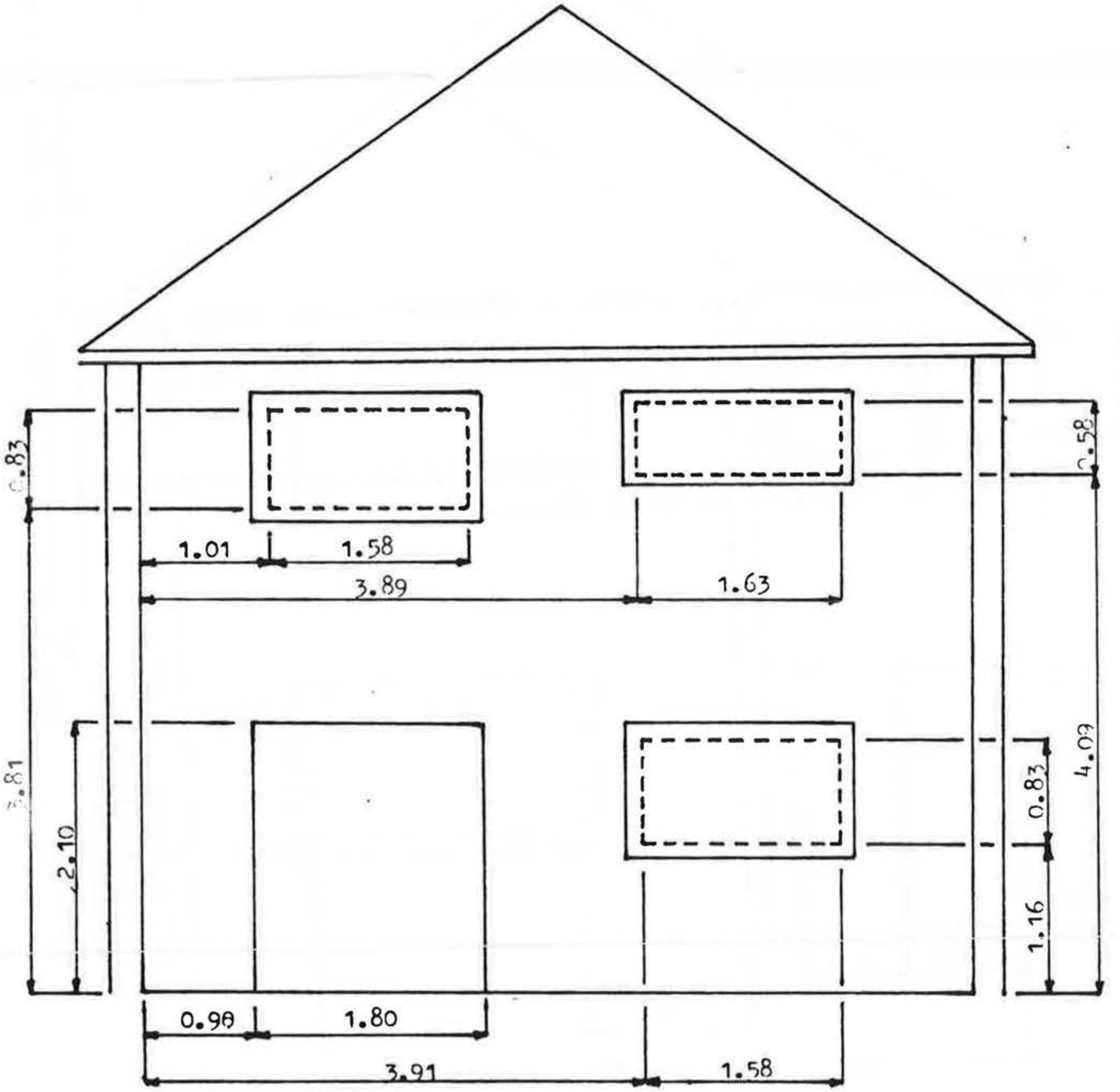


FIGURE 2 Detached house elevation (rear)

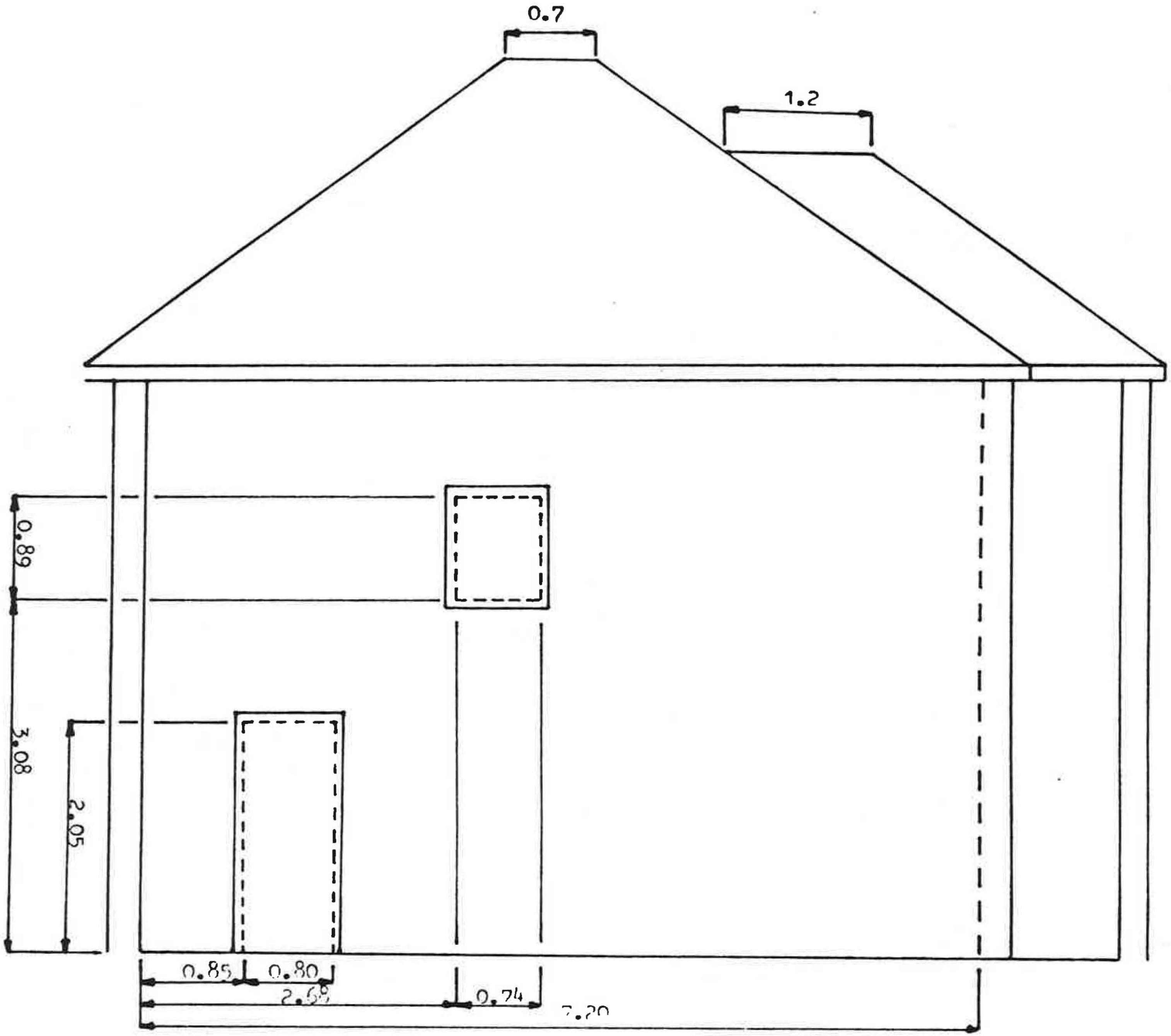
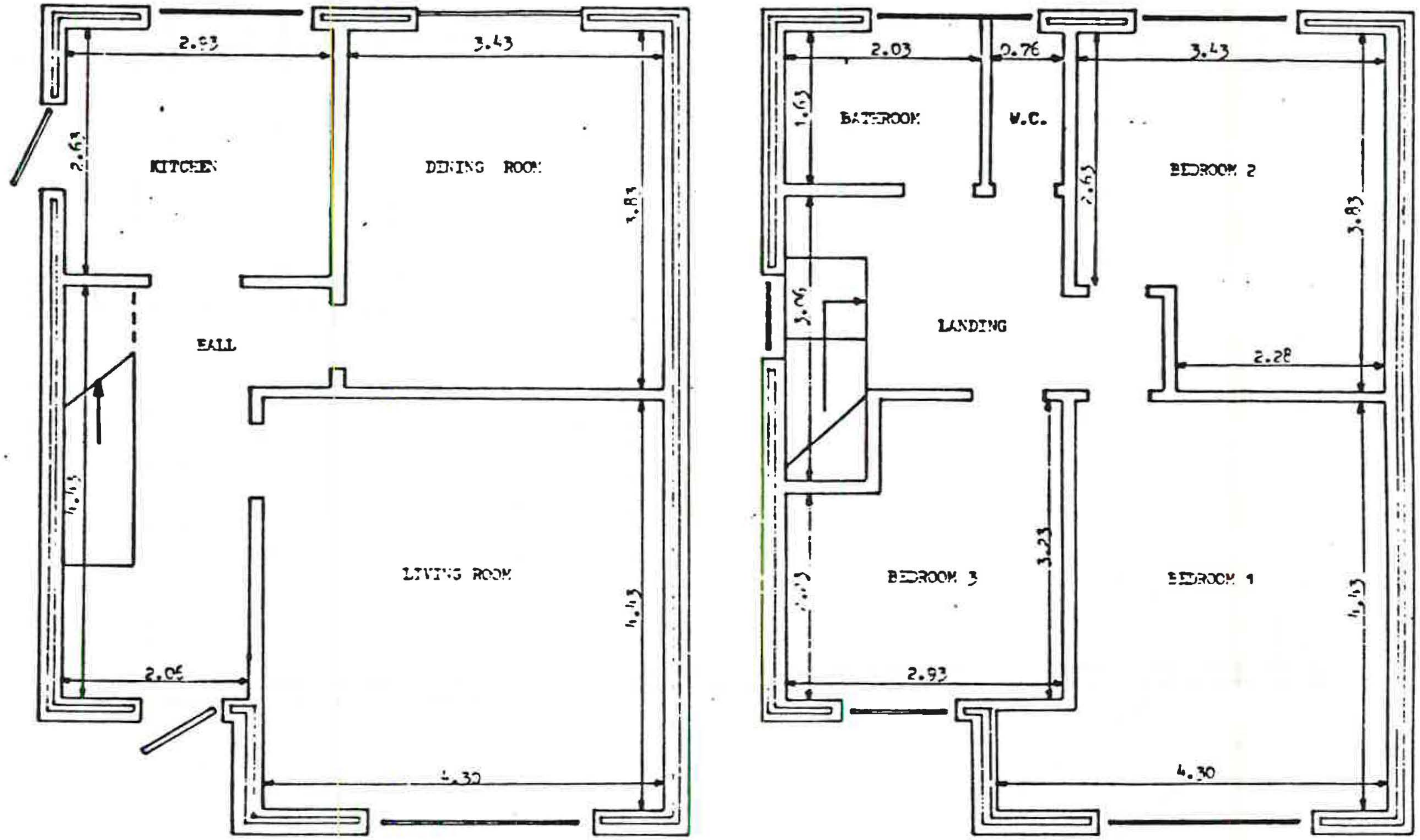


FIGURE 3 Detached house elevation (side)



GROUND FLOOR Floor to ceiling height = 2.50

FIRST FLOOR Floor to ceiling height = 2.35

FIGURE 4 Detached house plans

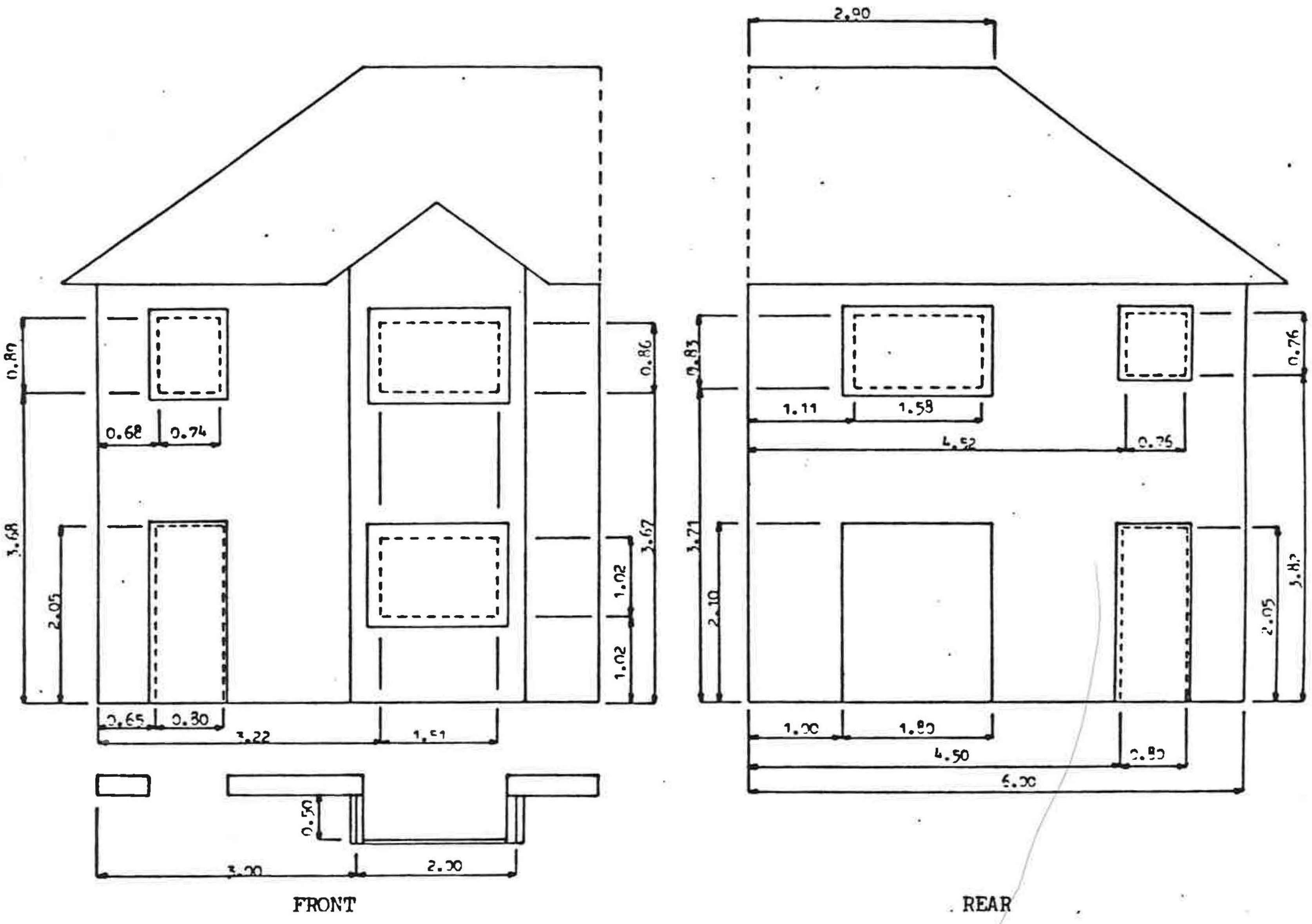


FIGURE 5 Semi-detached house elevations

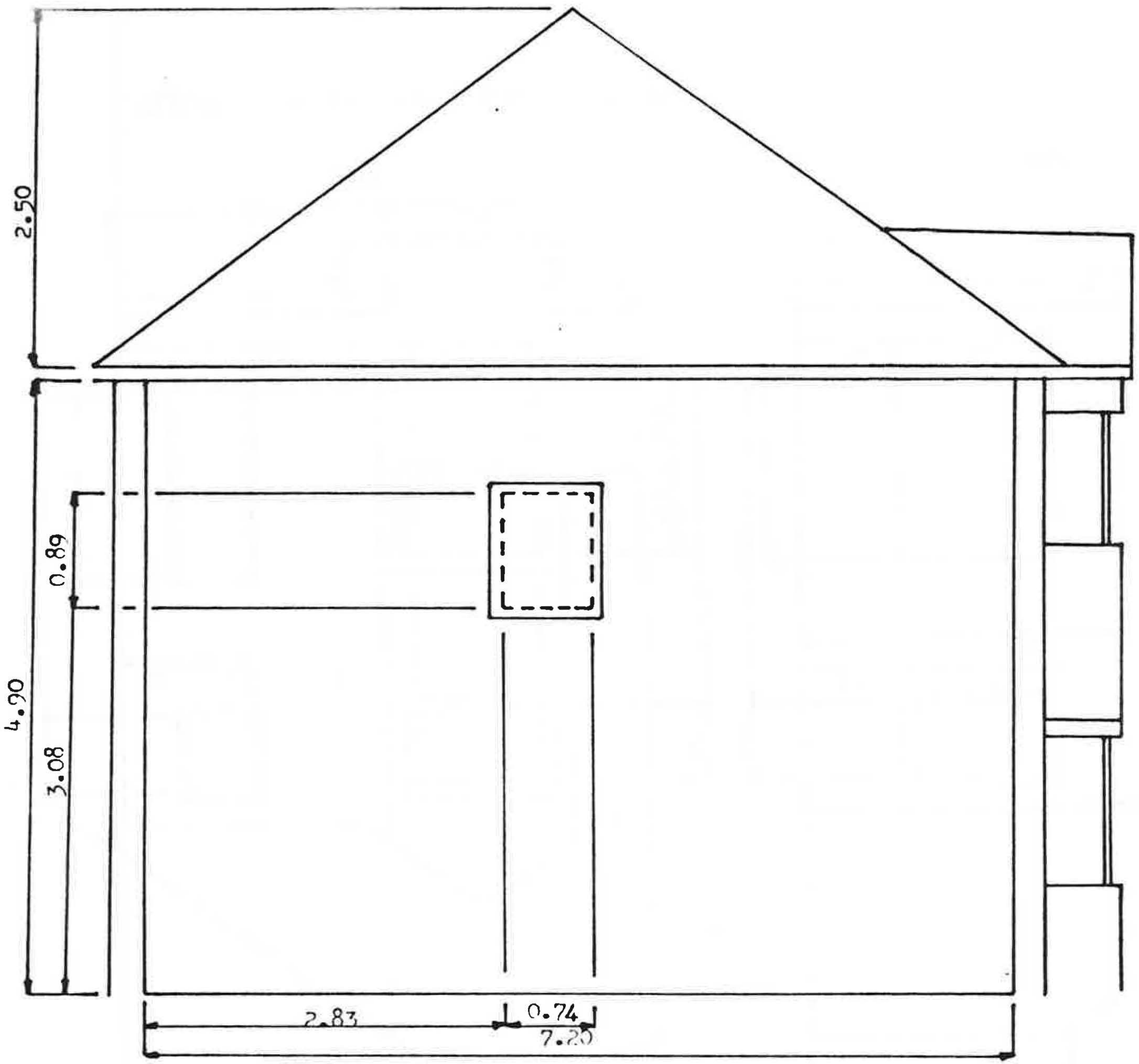
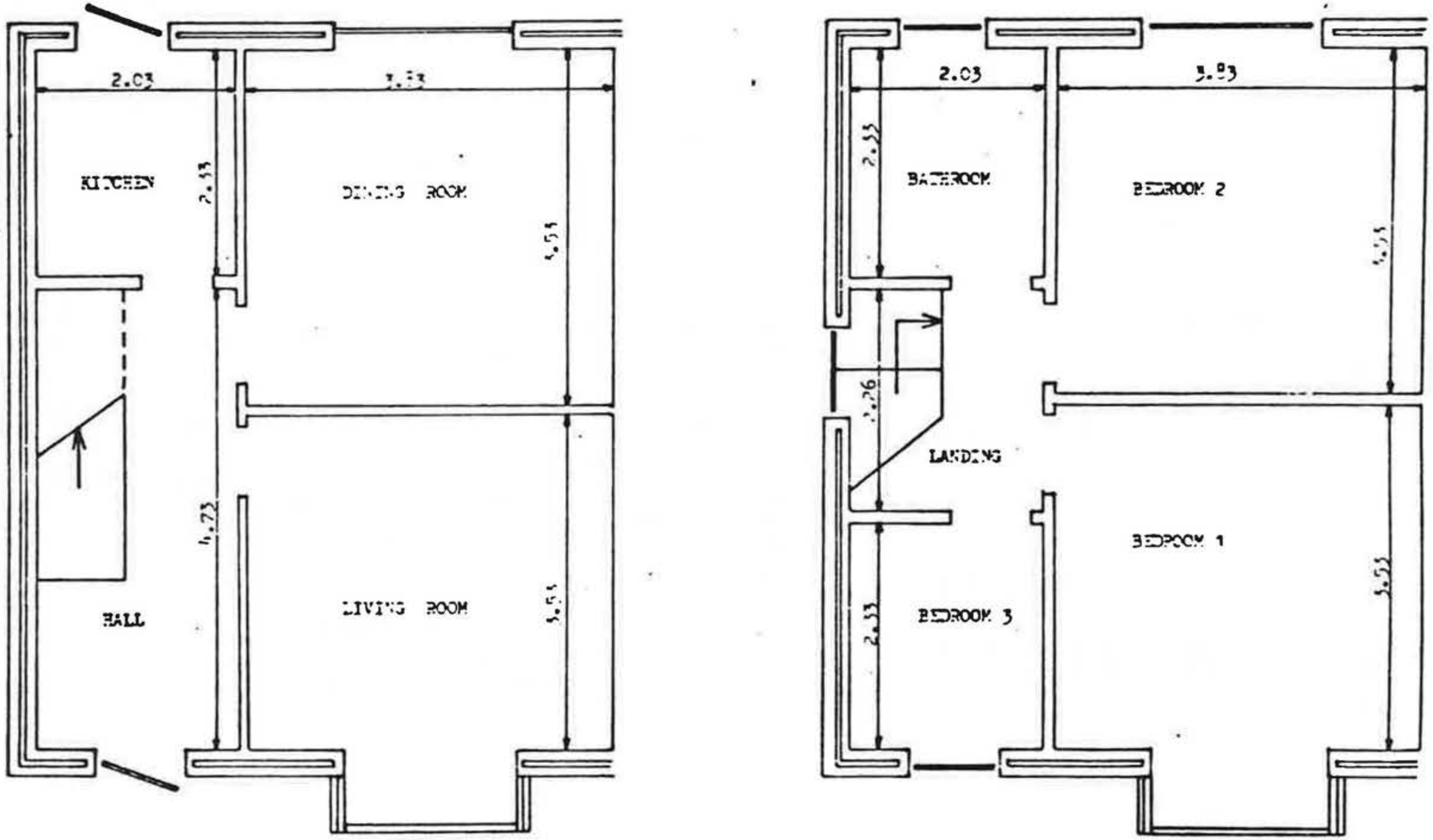


FIGURE 6 Semi-detached house elevation (side)



GROUND FLOOR Floor to ceiling height = 2.40

FIRST FLOOR Floor to ceiling height = 2.30

FIGURE 7 Semi-detached house plan

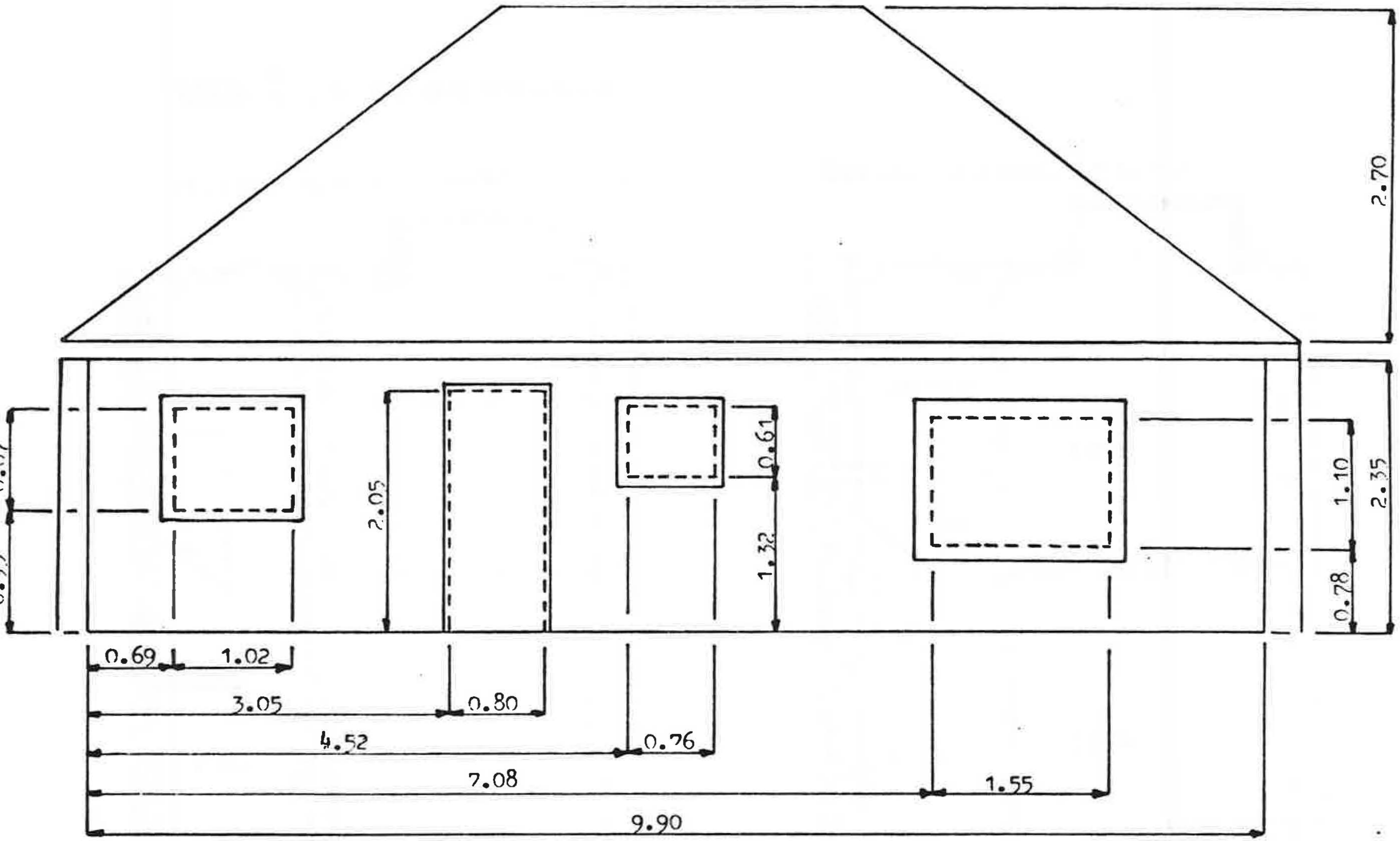


FIGURE 8 Bungalow elevation (front)

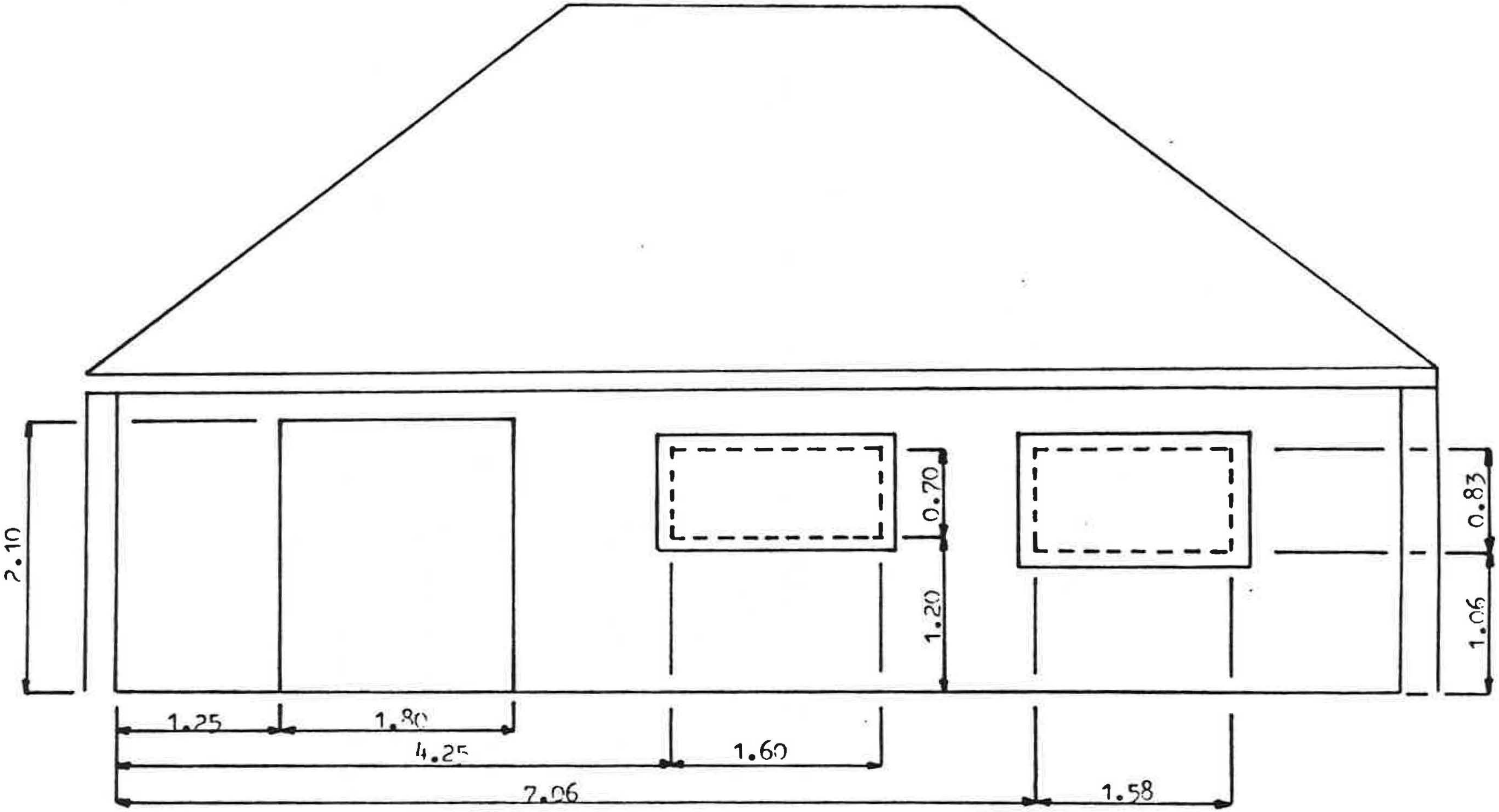


FIGURE 9 Bungalow elevation (rear)

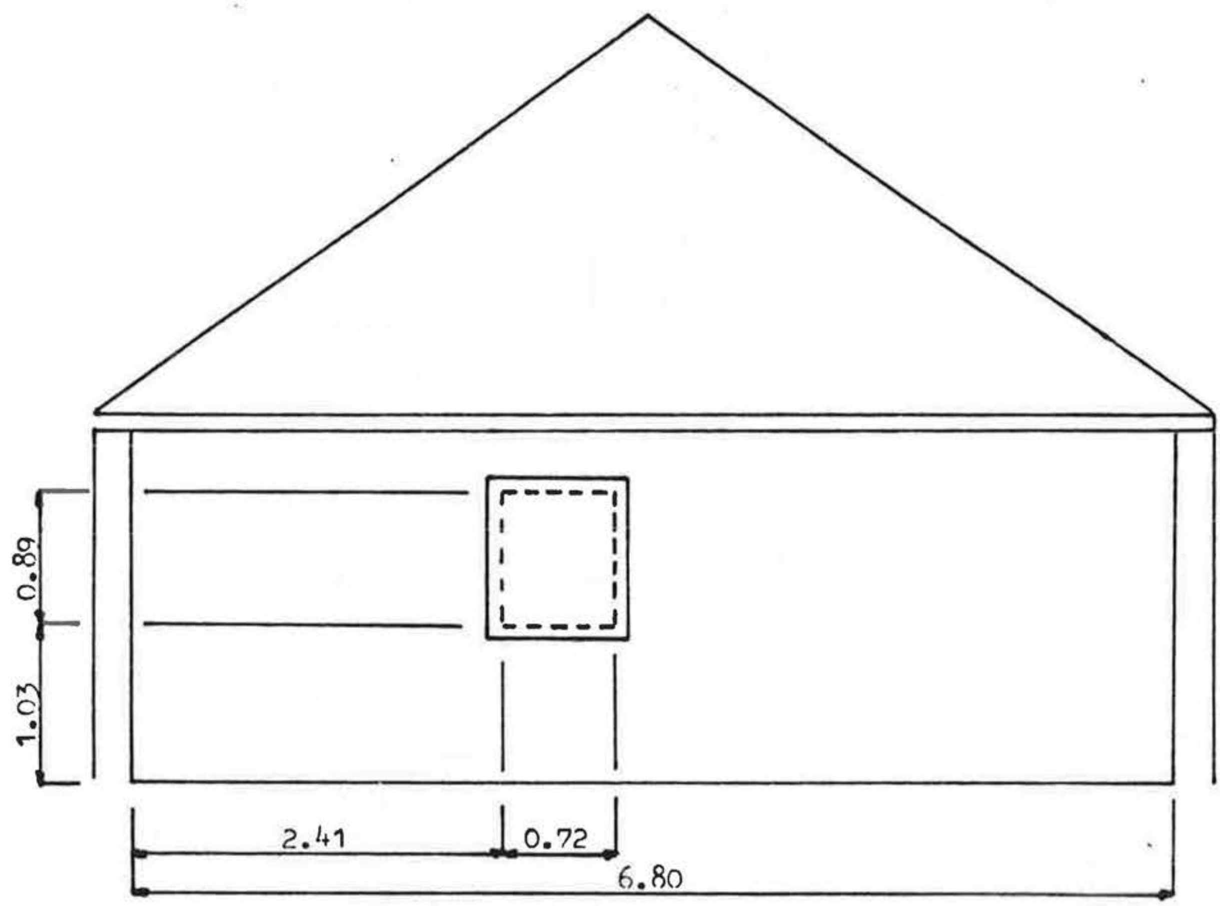


FIGURE 10 **Bungalow elevation (side)**

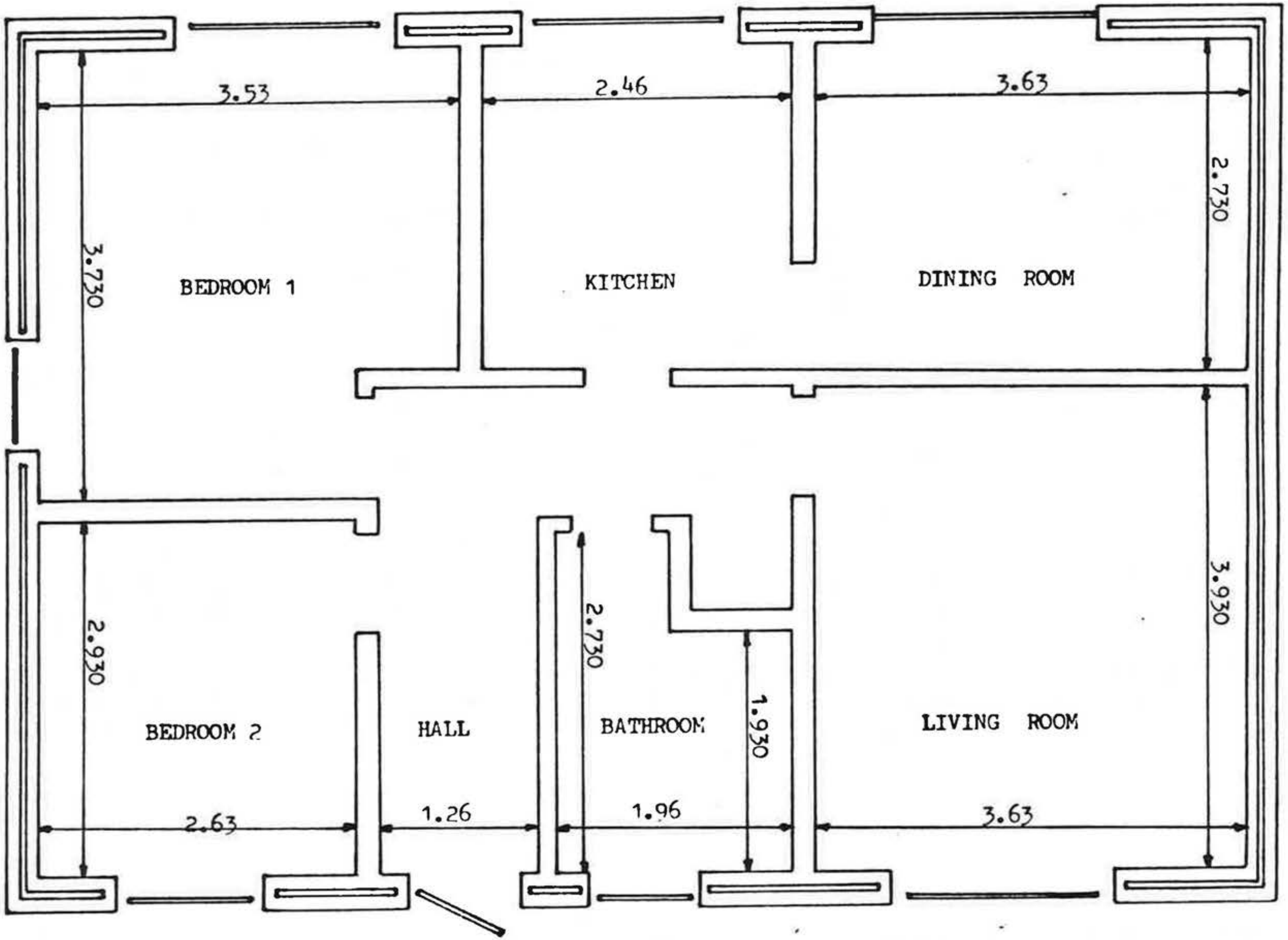


FIGURE 11 Bungalow plan   Floor to ceiling height = 2.35 m

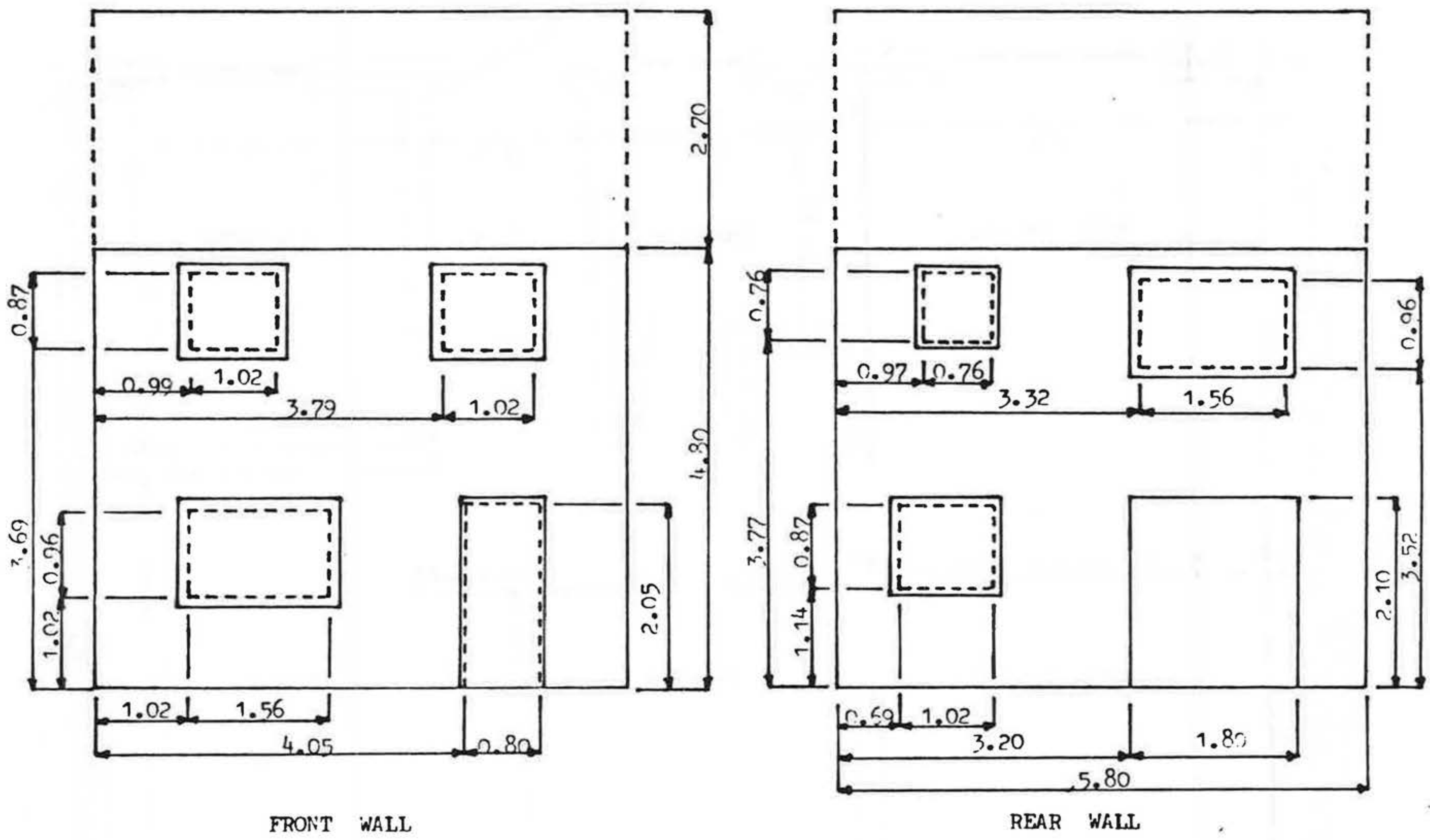
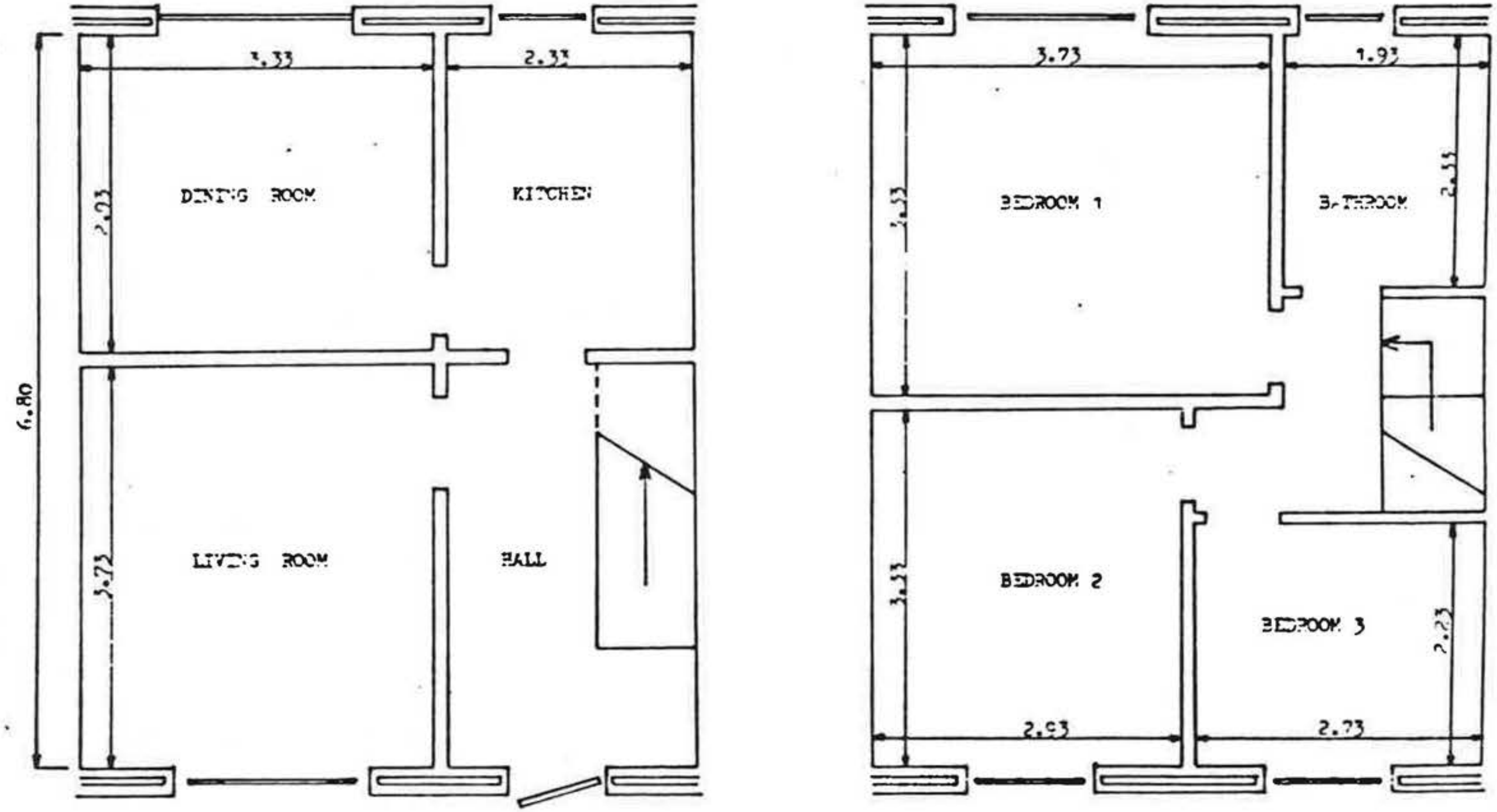


FIGURE 12 Post-1919 terrace elevations



GROUND FLOOR Floor to ceiling height = 2.30

FIRST FLOOR Floor to ceiling height = 2.30

FIGURE 13 Post-1919 terrace plan

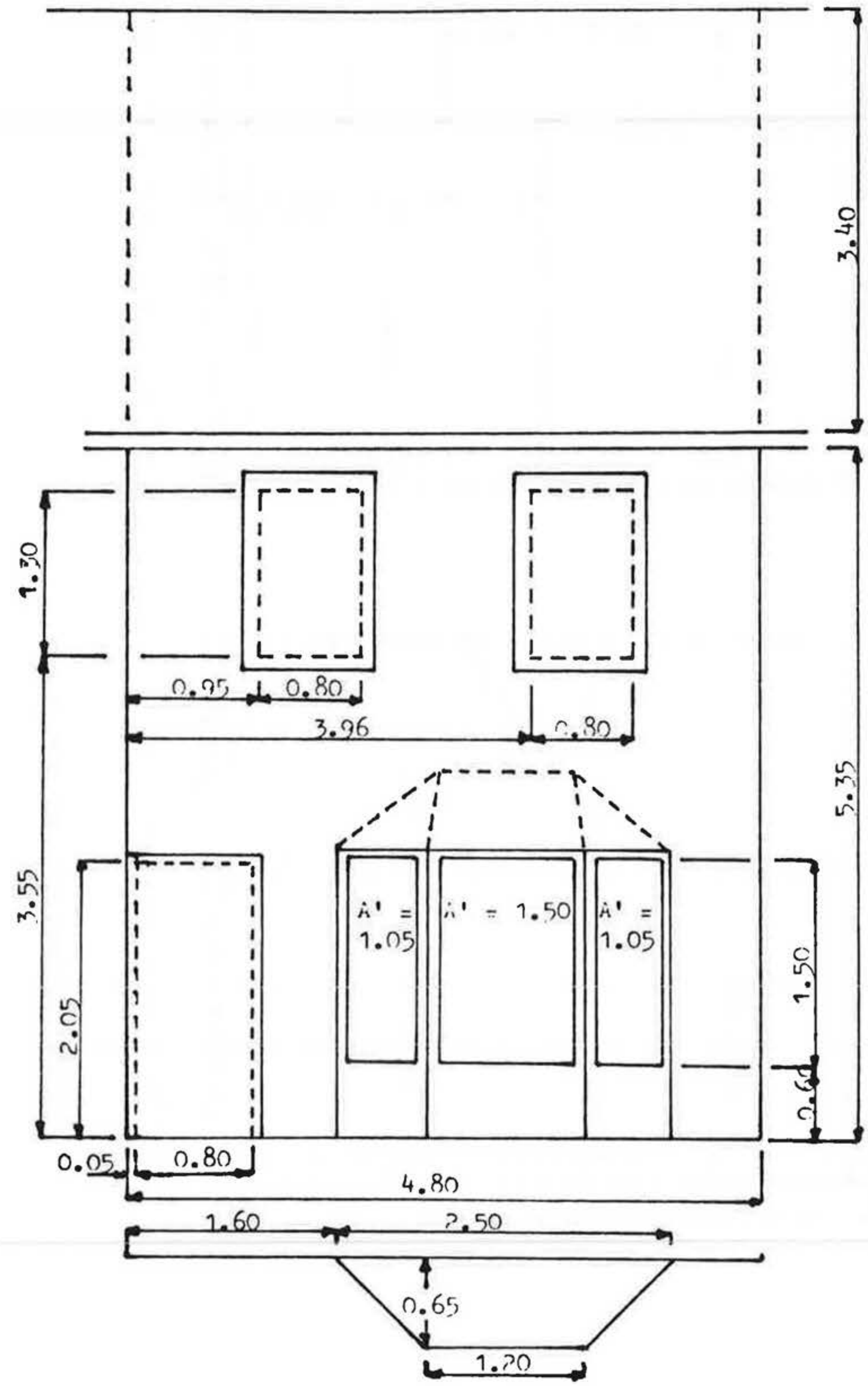
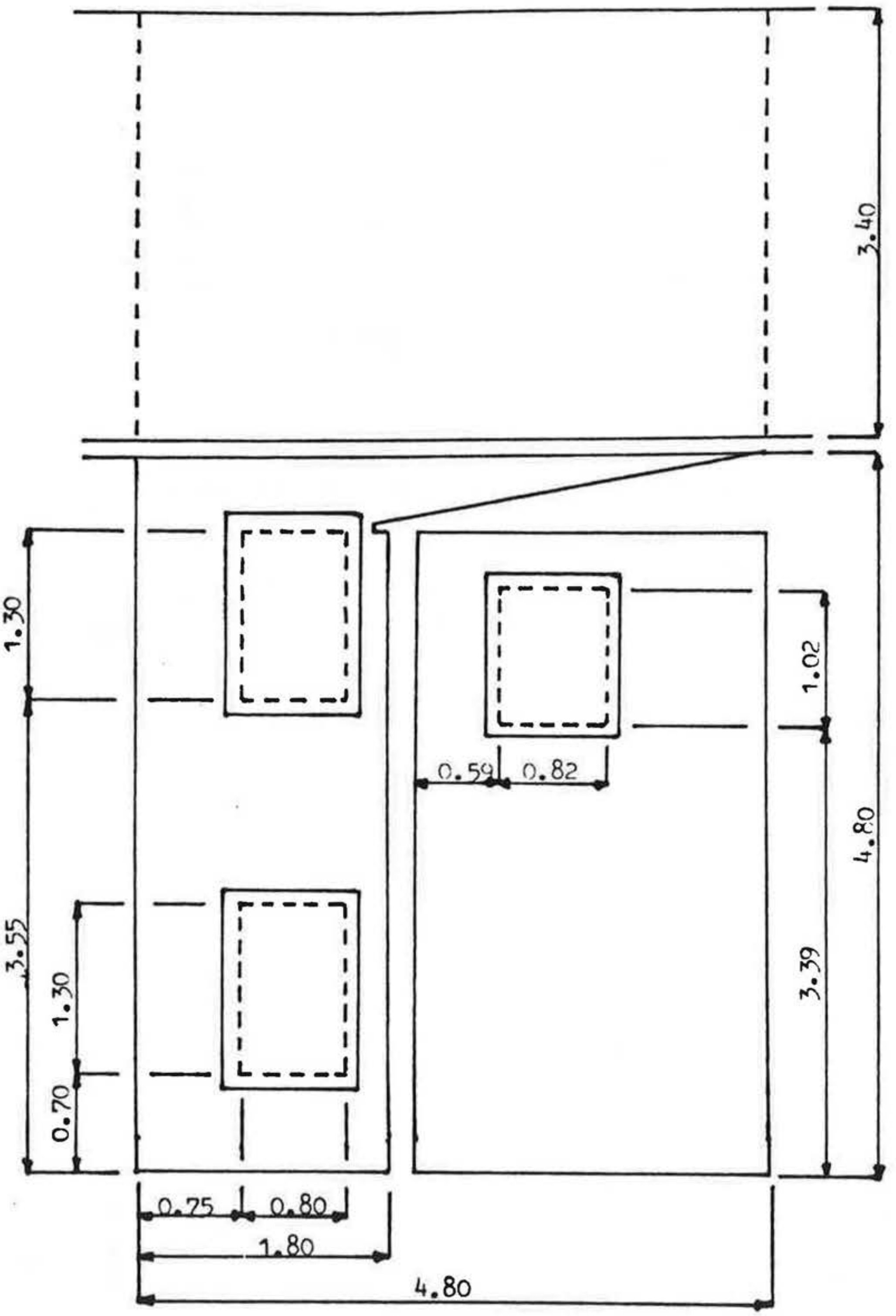


FIGURE 14 **Period terrace elevation (front)**



<u>FIGURE 15</u> Period terrace elevation (rear)

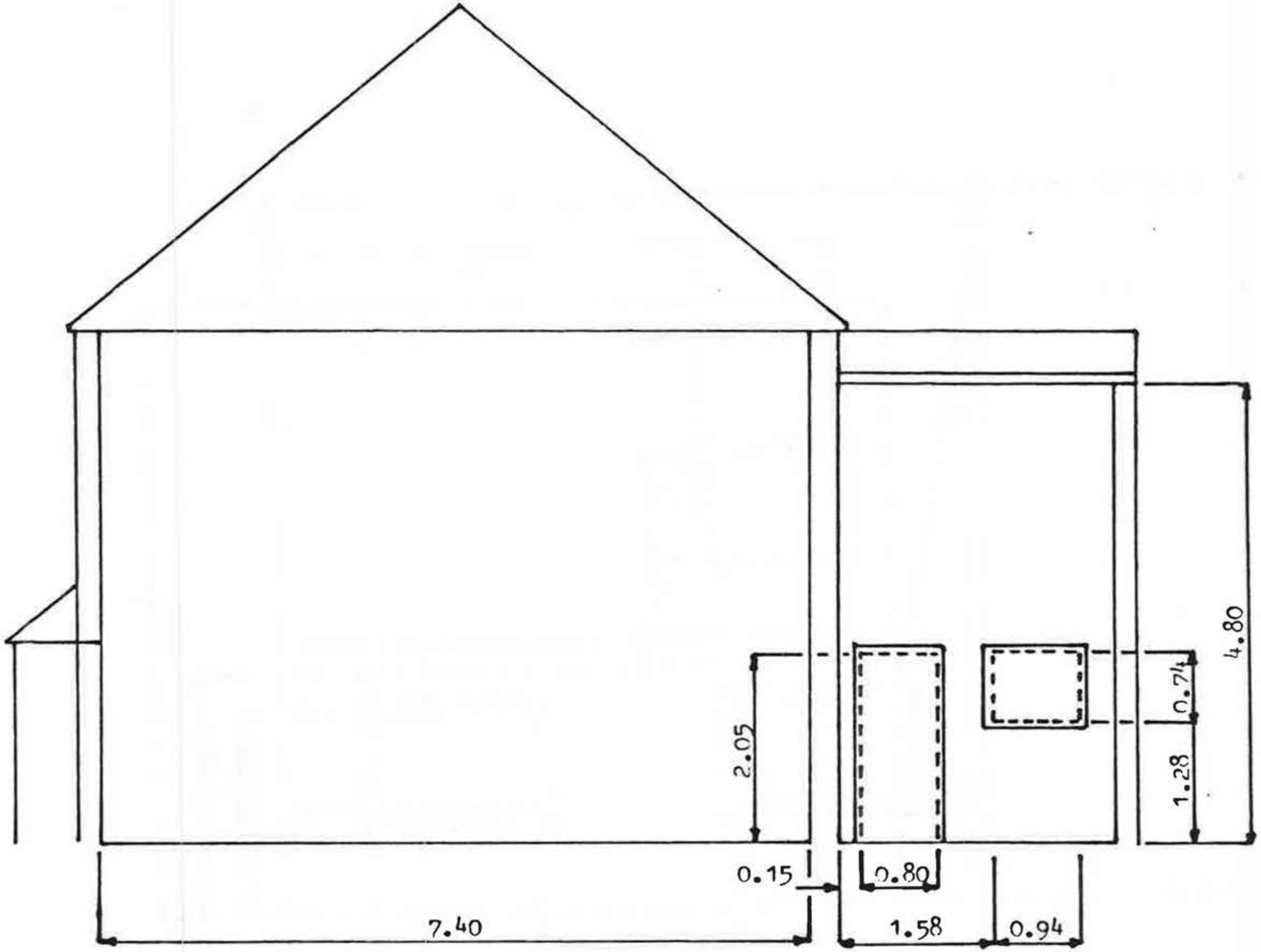


FIGURE 16 Period terrace elevation (side)

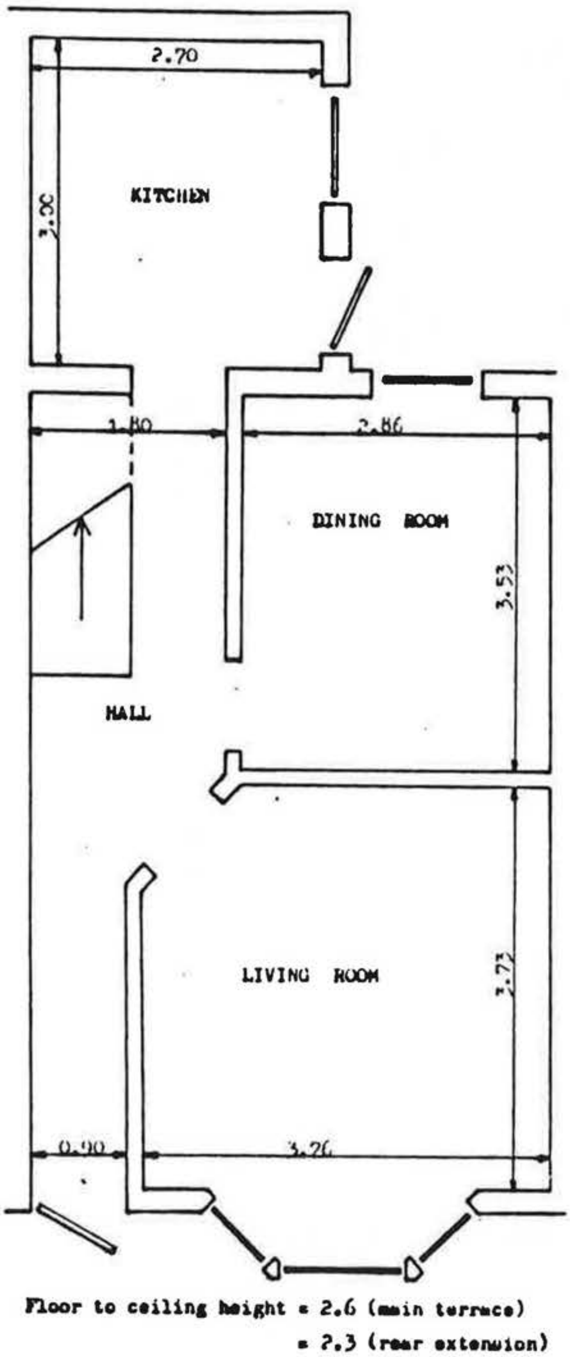
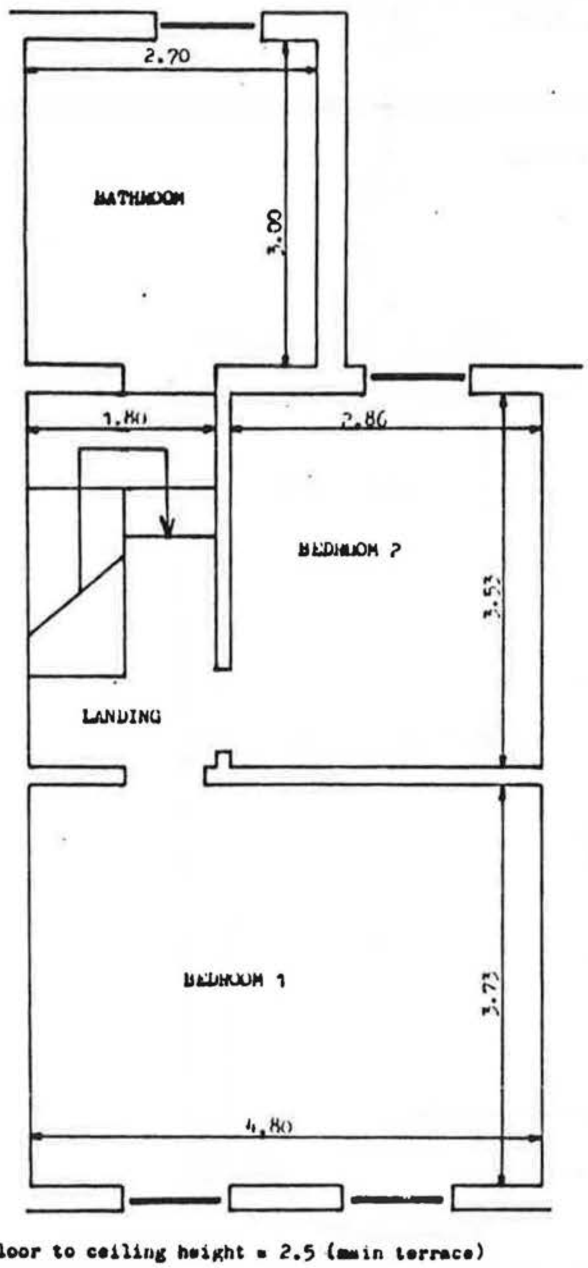


FIGURE 17 Period terrace ground floor plan



Floor to ceiling height = 2.5 (main terrace)
= 2.3 (rear extension)

FIGURE 18 Period terrace first floor plan

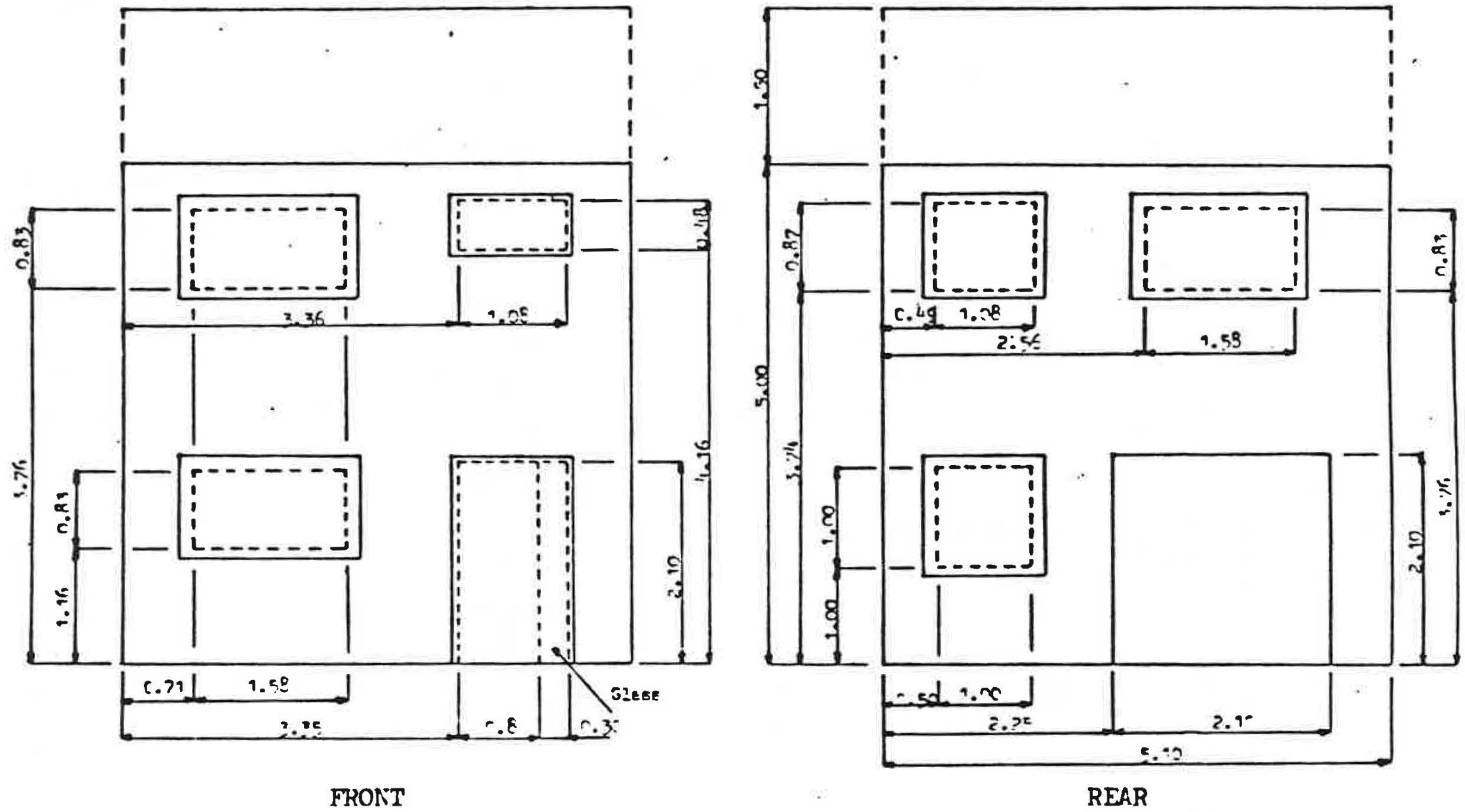


FIGURE 19 Timber framed house elevations

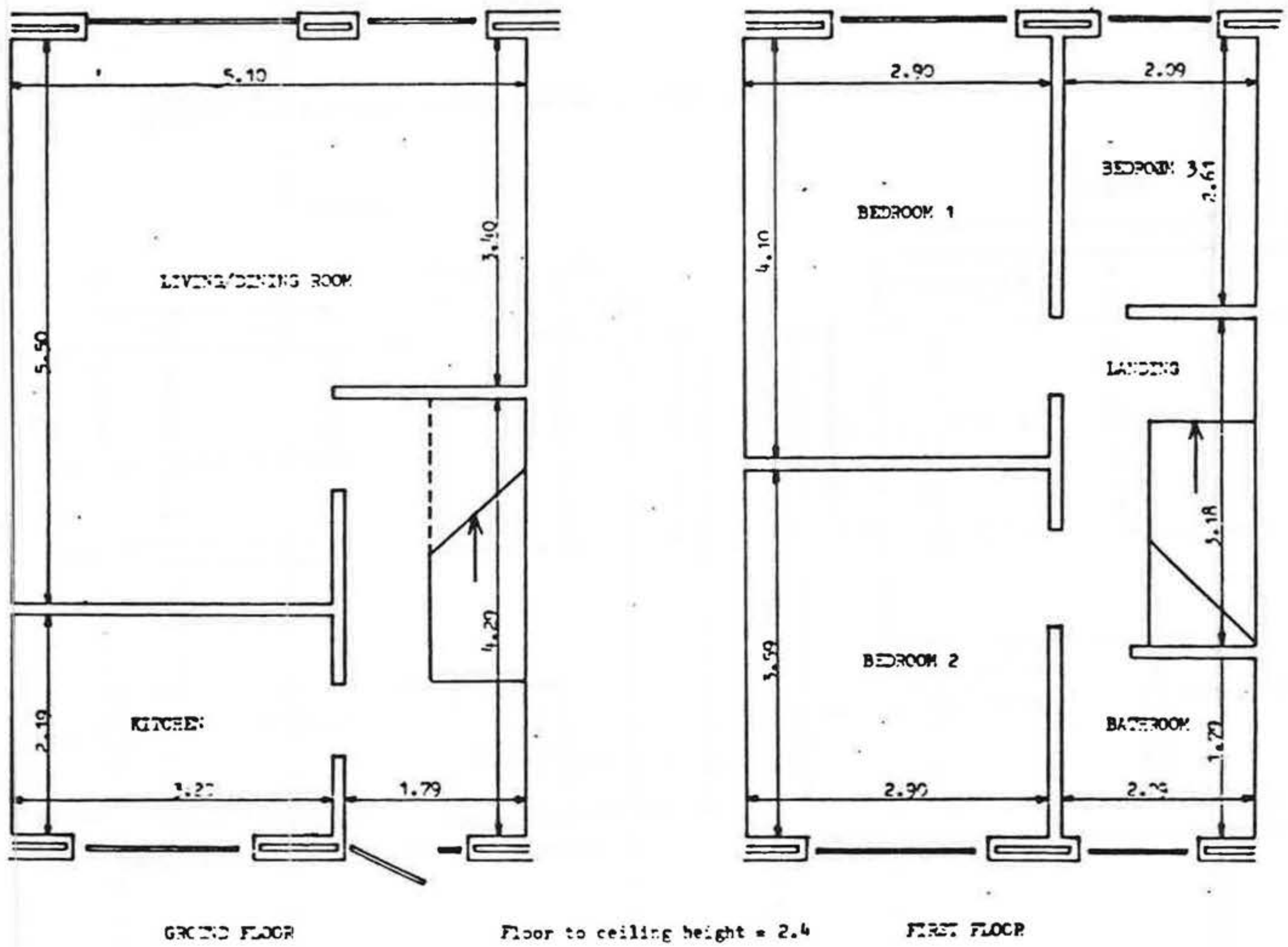


FIGURE 20 Timber framed house plans

5 DIMENSIONS OF MAJOR BUILDING ELEMENTS, INTERNAL TEMPERATURES AND DESIGN HEAT LOSS CALCULATIONS

Tables containing the dimensions of the major building elements and their associated design heat losses, for each room of each dwelling, follow (tables 14 to 25). These have been included for two reasons: a) to provide preliminary checking for modellers after having input the building to their particular model, and b) to allow radiators to be sized (see next section). It is recognised that some values of temperature and ventilation rates do not correspond to those used in the latest British Standard (BS 5449), which was revised after the results shown here were calculated. For those wishing to recalculate values to correspond with BS 5449, it is only necessary to follow the procedure below, substituting appropriate values from BS 5449.

The design heat loss Q (W) is calculated from

$$Q = [\sum(AU) + nV/3]\,(T_i - T_o)$$

where $\sum AU$ = area weighted U-value (W/K)
n = infiltration rate (ach)
V = volume of room (m^3)
T_i = internal temperature (°C)
and T_o = external temperature (°C)

The losses are based on an external temperature of -1°C and internal conditions given by CIBS (1978) for temperatures, and CIBS (1976) for infiltration rates (see following tables). There is assumed to be no interzonal air flows in any of the houses. Losses have assumed uncarpeted floors; all other U-values are as given in table 13 and section 3.2b. Larger window areas have been used to represent the closed wall cavities around windows, see section 4. The components making up the total design heat loss of each dwelling are illustrated as histograms in figure 21 overleaf.

6 RADIATOR SIZING AND HEATING CONTROL

Radiators have been selected from the Stelrad range to provide an output approximately equal to the room design heat losses + 20%. Details are given in tables 26 to 37. Radiators should be thought of as being positioned beneath windows, wherever possible. The radiant/convective split of all radiators is 0.2/0.8 respectively (this is a simplification used to cover both single and double panel radiators. A more appropriate split for double radiators may be used if required).

The following tables give design internal temperatures for each dwelling. These are given as dry resultant temperatures, which can be taken as equal proportions of air and mean radiant temperatures (0.5:0.5). Temperatures should be controlled to +/-1.5°C of the quoted values, although there is assumed to be no cooling plant and buildings might overheat in some cases. The times of operation of heating equipment during the heating season are 07.0-09.0 and 16.0-23.0 for the 'light' occupancy schedule (see section 8), and 07.0-23.0 for the 'heavy' occupancy schedule. These times can, however, be modified if required for a particular situation being investigated (to determine heating energy demand using some thermal simulation programs, the heating plant is given a very large capacity, and assumed to run continuously during 'on' periods).

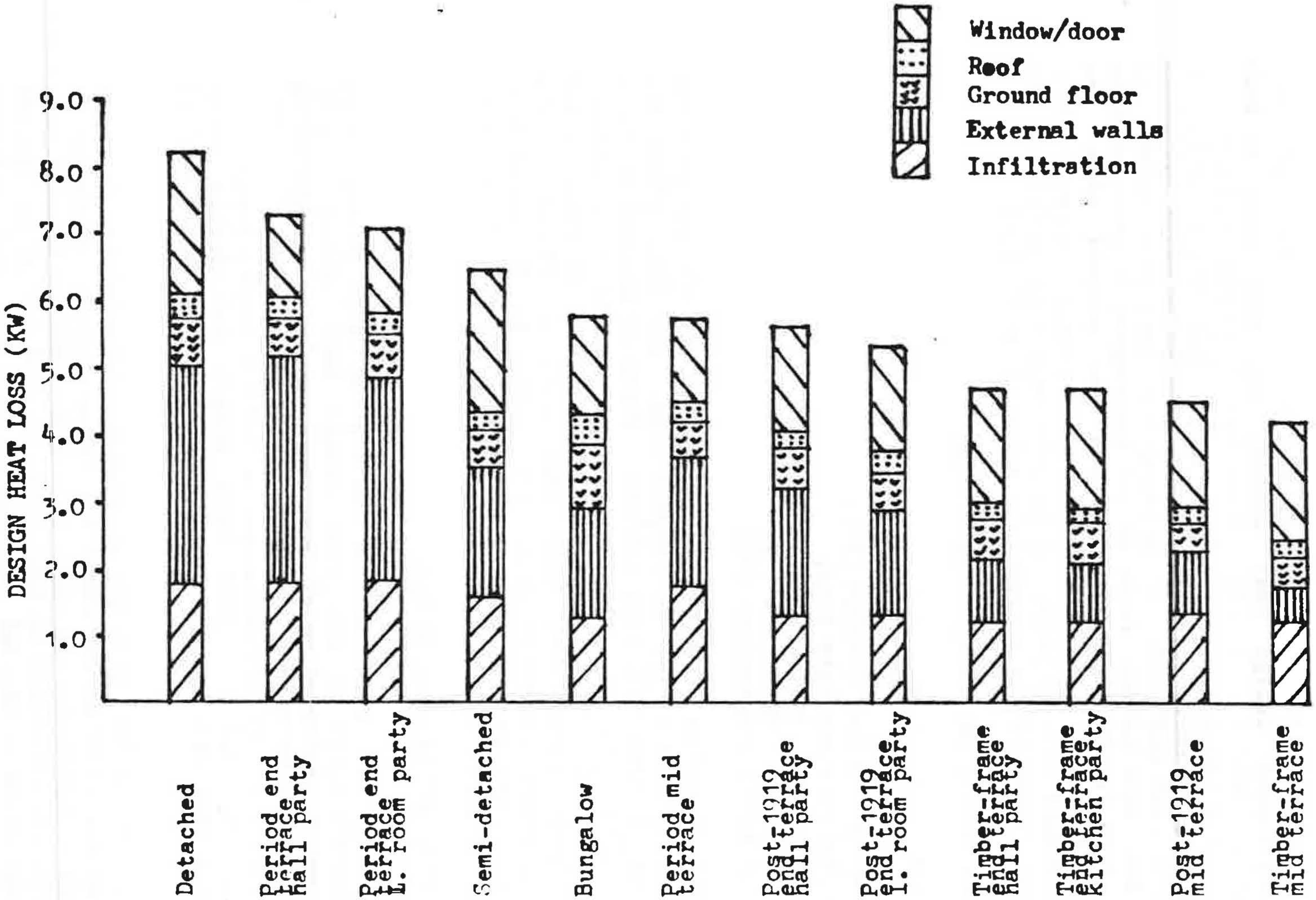


FIGURE 21 Design heat losses

Room type	Vol. (m^3)	Ext. wall area (m^2)	Ground floor area (m^2)	Roof area (m^2)	Window/ door area* (m^2)	Int. wall area (m^2) (adj. room temp. °C)	Int. floor/ ceiling area (m^2) (adj. room temp. °C)
Living	47.62	20.18	19.05	-	2.27 1.63	9.90 (16) 8.58 (21)	18.48 (18)
Dining	32.85	13.65	13.14	-	3.78 0.72	6.58 (18) 2.65 (16) 8.58 (21)	1.02 (16) 11.82 (18)
Kitchen	19.29	9.03	7.71	-	2.95 1.91	7.33 (16) 6.58 (21)	3.31 (22) 1.24 (18) 2.52 (16)
Hall and landing	43.71	19.62	10.05	7.91	1.21 2.59	7.33 (18) 12.55 (21) 4.77 (22) 19.39 (18)	2.52 (18) 5.81 (18) 1.02 (21)
B'room 1	37.88	19.51	-	16.12	1.75 1.35	2.26 (16) 14.78 (18)	16.12 (21)
B'room 2	27.78	14.66	-	11.82	1.31 1.07	6.77 (16) 9.31 (18)	11.82 (21)
B'room 3	20.26	8.40	-	8.62	0.89 0.80	9.31 (18) 8.58 (16)	2.36 (21) 5.81 (16)
Bathroom	7.78	7.40	-	3.31	0.63 0.57	4.77 (16) 3.83 (18)	3.31 (18)
W.C.	2.91	1.19	-	1.24	0.32 0.28	3.83 (18) 3.83 (22) 1.79 (16)	1.24 (18)

Notes: * = Total glazed and opaque areas of modified window and door openings (see sections 3.2b and 4). Glazing in doors is included in total glazed areas; frames are included in opaque ('door') areas.

TABLE 14 Detached house dimensions

Room: Design Temperature	Room: Design Infiltration rate	Infil-tration W	External wall W	Ground floor W	Roof W	Window/ door W	Internal wall W	Internal floor/ ceiling W	Total Design Heat loss W	Percentage of total
Living room 21°C	1 ach	349.21	621.54	310.13	-	368.94	93.06	85.93	1828.8	22.2%
Dining room 21°C	2 ach	481.80	420.42	213.92	-	425.70	62.02	62.87	1667.7	20.2%
Kitchen 18°C	2 ach	224.21	240.20	108.40	-	398.70	-9.55	-12.71	949.3	11.5%
Hall and landing 16°C	1.5 ach	371.54	466.96	126.43	47.06	222.72	-272.24	-33.73	928.7	11.3%
Bedroom 1 18°C	0.5 ach	119.95	518.97	-	107.20	254.90	8.50	-74.96	934.6	11.3%
Bedroom 2 18°C	0.5 ach	87.97	389.96	-	78.60	196.08	25.46	-54.96	723.1	8.8%
Bedroom 3 18°C	0.5 ach	64.16	223.44	-	57.32	137.26	32.26	7.04	521.5	6.3%
Bathroom 22°C	2 ach	119.29	238.28	-	26.65	118.68	82.61	20.52	606.0	7.3%
W.C 18°C	1.5 ach	27.65	31.65	-	8.25	49.02	-22.07	0	94.5	1.1%
Total Design Loss W		1845.8	3151.4	758.9	325.1	2172.0	0.0	0.0	8253	100%
Percentage of Total		22.4%	38.2%	9.2%	3.9%	26.3%	0.0%	0.0%	100%	

TABLE 15 Detached house design heat loss

Room type	Vol. (m^3)	Ext. wall area (m^2)	Ground floor area (m^2)	Roof area (m^2)	Window/ door area* (m^2)	Int. wall area (m^2) (adj. room temp. °C)	Int. floor/ ceiling area (m^2) (adj. room temp. °C)
Living	35.26	6.87	14.69	-	1.54 1.20	9.19 (21) 8.47 (16)	14.69 (18)
Dining	32.45	4.69	13.52	-	3.78 0.72	5.59 (18) 2.54 (16) 9.19 (21)	13.52 (18)
Kitchen	11.35	7.99	4.73	-	1.64 0.84	5.59 (21) 4.87 (16)	4.73 (22)
Hall and landing	33.60	17.63	9.60	4.59	1.21 2.59	11.01 (21) 4.87 (18) 9.55 (18) 4.67 (22)	4.73 (18)
B'room 1	33.79	6.73	-	14.69	1.30 1.06	14.17 (18) 2.44 (16)	14.69 (21)
B'room 2	31.10	6.41	-	13.52	1.31 1.07	5.36 (22) 8.81 (18) 2.44 (16)	13.52 (21)
B'room 3	10.88	8.71	-	4.73	0.66 0.66	5.36 (18) 4.67 (16)	4.73 (16)
Bathroom	10.88	8.87	-	4.73	0.58 0.59	4.67 (16) 5.36 (18)	4.73 (18)

Notes: * = Total glazed and opaque areas of modified window and door openings (see sections 3.2b and 4). Glazing in doors is included in total glazed areas; frames are included in opaque ('door') areas.

<u>TABLE 16</u> Semi-detached house dimensions

Room		Infil-tration	External wall	Ground floor	Roof	Window/door	Internal wall	Internal floor/ceiling	Total Design Heat loss	Percentage of total
Design Temperature	Design Infiltration rate	W	W	W	W	W	W	W	W	
Living room 21°C	1 ach	258.57	211.60	239.15	-	446.99	79.62	68.31	1304.2	20.3%
Dinin room 21°C	2 ach	475.93	144.45	220.11	-	425.70	55.40	62.87	1384.5	21.5%
Kitchen 18°C	2 ach	143.77	212.53	66.50	-	202.21	-13.22	-29.33	582.5	9.1%
Hall and landing 16°C	1.5 ach	285.60	419.59	120.77	27.31	222.72	-210.39	-14.66	850.9	13.2%
Bedroom 1 18°C	0.5 ach	107.00	179.02	-	97.69	357.44	9.17	-68.31	682.0	10.6%
Bedroom 2 18°C	0.5 ach	98.48	170.51	-	89.91	196.08	-31.13	-62.87	461.0	7.2%
Bedroom 3 18°C	0.5 ach	34.45	231.69	-	31.45	107.84	17.56	14.66	437.7	6.8%
Bathroom 22°C	2 ach	166.83	285.61	-	38.08	114.23	92.98	29.33	727.1	11.3%
Total Design Loss W		1570.6	1855.0	646.5	284.4	2073.2	0.0	0.0	6430	100%
Percentage of Total		24.4%	28.8%	10.1%	4.4%	32.2%	0.0%	0.0%	100%	

TABLE 17 Semi-detached house design heat losses

Room type	Volume (m^3)	External wall area (m^2)	Ground floor or roof area (m^2)	Window/ door area* (m^2)	Int. wall area (m^2) (adj. room temp. °C)
Living	33.53	14.77	14.27	1.70 1.30	8.53 (21) 4.54 (22) 4.37 (16)
Dining	23.29	10.45	9.91	3.78 0.72	8.53 (21) 6.42 (18)
Kitchen	15.79	3.68	6.72	1.12 0.98	6.42 (21) 6.42 (18) 5.78 (16)
Hall	18.59	0.49	7.91	0.55 1.93	16.48 (18) 4.37 (21) 12.24 (22)
B'room 1	28.83	13.34	12.27	1.96 1.72	12.60 (18) 3.81 (16)
B'room 2	18.12	11.39	7.71	0.89 0.80	6.18 (18) 6.89 (16)
Bathroom	10.60	3.62	4.51	0.46 0.51	12.24 (16) 4.54 (21)

Notes: * = Total glazed and opaque areas of modified window and door openings (see sections 3.2b and 4). Glazing in doors is included in total glazed areas; frames are included in opaque ('door') areas.

TABLE 18 Bungalow dimensions

Room		Infil- tration	External wall	Ground floor	Roof	Window/ door	Internal wall	Total Design Heat loss	Percentage of total
Design Temperature	Design Infiltration rate	W	W	W	W	W	W	W	
Living room									
21°C	1 ach	245.89	454.92	232.32	109.88	283.80	32.54	1359.4	23.2%
Dinin room									
21°C	2 ach	341.59	321.86	161.33	76.31	425.70	36.21	1363.0	23.3%
Kitchen									
18°C	2 ach	200.01	97.89	94.48	44.69	171.57	-14.48	594.2	10.1%
Hall									
16°C	1.5 ach	158.02	11.66	99.51	47.06	126.23	-241.11	201.4	3.4%
Bedroom 1									
18°C	0.5 ach	91.30	354.84	172.52	81.60	303.92	14.33	1018.5	17.4%
Bedroom 2									
18°C	0.5 ach	57.38	302.97	108.40	51.27	137.26	25.91	683.2	11.7%
Bathroom									
22°C	2 ach	162.53	116.56	76.76	36.31	97.91	146.60	636.7	10.9%
Total Design Loss W		1256.7	1660.7	945.3	447.1	1546.4	0.0	5856	100%
Percentage of Total		21.5%	28.4%	16.1%	7.6%	26.4%	0.0%	100%	

TABLE 19 Bungalow design heat losses

Room type	Volume (m^3)	External wall area (m^2)			Ground floor area (m^2)	Roof area (m^2)	Window/ door area (m^2)	Internal wall area (m^2) (adjacent room temp °C)	Internal floor/ ceiling area (m^2) (adjacent room temp °C)
		Hall party	Mid	Living-room party					
Living	28.57	13.54	4.96	4.96	12.42	-	1.50 1.18	8.58 (16) 7.66 (21)	12.06 (18) 0.36 (16)
Dining	22.45	9.90	3.16	3.16	9.76	-	3.78 0.72	6.74 (18) 7.66 (21)	9.76 (18)
Kitchen	15.71	3.68	3.68	10.42	6.83	-	0.89 0.80	5.36 (16) 6.74 (21)	4.80 (22) 1.06 (16) 0.97 (18)
Hall and Landing	30.46	2.88	2.88	8.04	8.69	4.55	0.55 1.93	8.58 (21 5.36 (18) 4.44 (22) 11.98 (18)	5.83 (18) 1.02 (18)
Bedroom 1	28.57	13.54	5.88	5.88	-	12.42	1.50 1.18	5.36 (22) 3.50 (16) 6.14 (18)	11.32 (21) 0.96 (18) 0.13 (16)
Bedroom 2	22.45	14.40	5.06	5.06	-	9.76	0.89 0.80	11.87 (18) 2.21 (16)	9.76 (21)
Bedroom 3	14.01	4.60	4.60	9.73	-	6.09	0.89 0.80	6.28 (16) 5.13 (18)	0.74 (21) 5.35 (16)
Bathroom	10.35	3.28	3.28	8.64	-	4.50	0.58 0.59	4.44 (16) 5.36 (18)	4.50 (18)

TABLE 20 Post-1919 terrace dimensions

Room			External Wall			Ground floor						Total design heat loss percentage of total		
Design temperature	Design infiltration rate	Infiltration W	Hall party W	Mid W	Living room party W	End W	Mid W	Roof W	Window/ door W	Internal wall W	Internal floor/ ceiling W	Hall party W	Mid W	Living room party W
Living room 21°C	1 ach	209.51	417.05	152.77	152.77	202.20	150.28	-	255.42	80.65	58.87	1223.7 21.9%	907.7 20.1%	959.4 18.2%
Dining room 21°C	2 ach	329.27	304.92	97.33	97.33	158.89	118.10	-	425.70	38.01	45.38	1302.2 23.3%	1053.8 23.3%	1094.6 20.7%
Kitchen 18°C	2 ach	98.99	97.89	97.89	177.17	96.05	71.37	-	137.26	-17.86	-26.47	485.8 8.7%	461.2 10.2%	665.1 12.6%
Hall and landing 16°C	1.5 ach	258.91	68.54	68.54	191.35	109.32	81.25	27.07	126.38	-195.93	-21.24	372.9 6.7%	344.8 7.6%	495.7 9.4%
Bedroom 1 18°C	0.5 ach	90.47	360.16	156.41	156.41	-	-	82.59	220.59	-27.15	-52.24	674.4 12.1%	470.7 10.4%	470.7 8.9%
Bedroom 2 18°C	0.5 ach	71.09	383.04	134.60	134.60	-	-	64.90	137.26	8.31	-45.38	619.2 11.1%	370.8 8.2%	370.8 7.0%
Bedroom 3 18°C	0.5 ach	44.37	122.36	122.36	258.82			40.50	137.26	23.61	13.14	381.2 6.8%	381.2 8.4%	517.7 9.8%
Bathroom 22°C	2 ach	158.70	105.62	105.62	278.21	-	-	36.23	114.23	40.39	27.90	533.1 9.5%	533.1 11.8%	705.7 13.4%
Total Design heat loss W		1361.3	1859.6	935.5	1546.7	566.4	421.0	251.3	1554.0	0.0	0.0	5593	4523	5280
Hall party Mid Kitchen party		24.3% 30.1% 25.8%	33.2% - -	- 20.7% -	 - 29.3%	10.1% 10.7%	 9.3% 	4.5% 5.6% 4.8%	27.8% 34.5% 29.4%	0.0% 0.0% 0.0%	0.0% 0.0% 0.0%			

TABLE 21 Post-1919 terrace design heat losses

Room type	Volume (m³)	External wall area (m²)			Ground floor area (m²)	Roof area (m²)	Window/ door area (m²)	Internal wall area (m²) (adjacent room temp °C)	Internal floor/ ceiling area (m²) (adjacent room temp °C)
		Hall Party	Mid	Living-room party					
Living	39.57	16.93	7.23	7.23	15.22	-	2.52 1.08	11.67 (16) 7.44 (21)	14.02 (18)
Dining	26.26	12 52	3.34	3.34	10.10	-	1.04 0.45	7.44 (21) 9.18 (16) 1.75 (16)	10.10 (18)
Kitchen	18.63	10.22	10.22	17.12	8.10	-	2.34 1.13	4.14 (16) 1.75 (21)	18.10 (22)
Hall and landing	41.62	0.45	0.45	9.28	9.90	6.35	0.55 1.93	4.41 (18) 20.85 (21) 13.33 (18) 4.14 (22)	3.36 (18)
Bedroom 1	44.75	18.33	9.00	18.33	-	17.90	2.08 0.89	4.50 (16) 7.15 (18)	14.02 (21) 3.36 (16)
Bedroom 2	22.25	11.98	3.15	3.15	-	10.10	1.04 0.45	7.15 (18) 8.83 (16) 1.75 (22)	10.10 (21) 0.74 (21)
Bathroom	18.63	11.91	11.91	18.81	-	8.10	0.84 0.36	4.14 (16) 1.75 (18)	8.10 (18)

TABLE 22 Period terrace dimensions

Room			External Wall			Ground floor						Total design heat loss percentage of total		
Design temperature	Design infiltration rate	Infiltration W	Hall party W	Mid W	Living room party W	Mid & room party W	Living room party W	Roof W	Window/door W	Internal wall W	Internal floor/ceiling W	Hall party W	Mid W	Living room party W
Living room 21°C	1 ach	290.18	741.20	316.53	316.53	200.90	200.90	-	340.56	109.70	65.19	1747.7	1323.1	1323.1
Dining room 21°C	2 ach	385.15	548.13	146.23	146.23	133.32	133.32	-	141.90	96.16	-46.97	1351.6 18.4%	949.7 16.3%	949.7 13.4%
Kitchen 18°C	2 ach	235.98	386.42	386.42	647.31	146.21	190.84	-	236.11	5.70	-50.22	960.2 13.1%	960.2 16.5%	265.7 17.9%
Hall and landing 16°C	1.5 ach	353.77	15.22	15.22	313.94	100.98	100.98	37.78	96.39	-308.38	-10.42	285.3 3.9%	285.3 4.9%	584.1 8.2%
Bedroom 1 18°C	0.5 ach	141.71	693.06	340.29	693.06	-	-	119.04	245.10	16.92	-54.78	1161.1 15.8%	808.3 13.9%	1161.1 16.4%
Bedroom 2 18°C	0.5 ach	79.96	452.96	119.10	119.10	-	-	67.17	122.55	20.04	-46.97	695.7 9.5%	361.9 6.2%	361.9 5.1%
Bathroom 22°C	2 ach	285.66	545.12	545.12	860.93	-	-	65.21	118.68	59.86	50.22	1124.8 15.4%	1124.8 19.3%	1440.6 20.3%
Total Design heat loss W		1772.4	3382.1	1868.9	3097.1	581.4	626.04	289.2	1301.3	0.0	0.0	7326	5813	7086
Hall party Mid Living room party		24.2% 30.5% 25.0%	46.2% - -	- 32.2% -	- - 43.7%	7.9% 10.0% -	- - 8.8%	3.9% 5.0% 4.1%	17.8% 22.4% 18.4%	0.0% 0.0% 0.0%	0.0% 0.0% 0.0%			

TABLE 23 Period terrace design heat losses

Room type	Volume (m³)	External wall area (m²)			Ground floor area (m²)	Roof area (m²)	Window/ door area (m²)	Internal wall area (m²) (adjacent room temp °C)	Internal floor/ ceiling area (m²) (adjacent room temp °C)
		Hall Party	Mid	Living-room party					
Living and dining	57.74	18.37	5.17	13.33	24.06	-	5.41 1.65	7.68 (18) 9.07 (16)	11.89 (18) 5.45 (18) 3.74 (18) 1.80 (16)
Kitchen	16.82	10.54	5.28	5.28	7.01	-	1.31 1.07	7.68 (21) 5.26 (16)	0.34 (22) 0.06 (16) 6.35 (18)
Hall and landing	34.39	1.15	1.15	19.08	7.68	6.65	1.19 2.03	5.26 (18) 9.07 (21) 5.02 (22) 12.39 (18)	3.20 (22) 0.06 (18) 1.80 (21)
Bedroom 1	28.54	14.40	4.56	4.56	-	11.89	1.31 1.07	6.26 (18) 6.96 (18) 3.31 (16)	11.89 (21)
Bedroom 2	24.98	13.18	4.56	4.56	-	10.41	1.31 1.07	6.96 (18) 4.30 (22) 4.06 (16)	6.35 (18) 3.74 (21)
Bedroom 3	13.08	3.34	3.34	9.60	-	5.45	0.94 0.83	6.26 (18) 5.02 (16)	5.45 (21)
Bathroom	8.98	3.97	3.97	8.27	-	3.74	0.52 0.54	3.20 (18) 5.02 (16)	3.20 (16) 0.34 (18)

TABLE 24 Timber framed house dimensions

Room			External Wall			Ground floor						Total design heat loss percentage of total		
Design temperature	Design infiltration rate	Infiltration W	Hall party W	Mid W	Living room party W	Mid W	End W	Roof W	Window/door W	Internal wall W	Internal floor/ceiling W	Hall party W	Mid W	Kitchen party W
Living and dining room 21°C	1.5 ach	635.14	202.07	56.87	146.63	291.13	391.70	-	668.82	119.68	111.97	2129.4 45.2%	1883.6 45.0%	2073.9 44.2%
Kitchen 18°C	2 ach	213.05	100.13	50.16	50.16	73.25	98.56	-	196.08	-21.91	-1.92	584.0 12.4%	508.7 12.1%	534.0 11.4%
Hall and landing 16°C	1.5 ach	292.32	9.78	9.78	162.18	71.81	96.61	39.57	230.27	-193.85	-43.90	430.8 9.1%	406.0 9.7%	583.2 12.4%
Bedroom 1 18°C	0.5 ach	90.38	136.80	43.32	43.32	-	-	79.07	196.08	11.59	-55.29	458.6 9.7%	365.2 8.7%	365.2 7.8%
Bedroom 2 18°C	0.5 ach	79.10	125.21	-43.32	43.32	-	-	69.23	196.08	-15.89	-17.39	436.3 9.3%	354.5 8.5%	354.5 7.6%
Bedroom 3 18°C	0.5 ach	41.42	31.73	31.73	91.20	-	-	36.24	137.26	17.57	-25.34	238.9 5.1%	238.9 5.7%	298.4 6.4%
Bathroom 22°C	2 ach	137.69	45.66	45.66	95.11	-	-	30.11	103.85	82.81	31.87	432.0 9.2%	432.0 9.2%	481.4 10.3%
Total Design heat loss W		1489.1	541.4	280.8	631.9	436.2	586.9	254.2	1728.4	0.0	0.0	4710	4189	4691
Hall party Mid Kitchen party		31.6% 35.5% 31.7%	13.8% - -	- 6.7% -	- - 13.5%	- 10.4% -	12.5% - 12.5%	5.4% 6.1% 5.4%	36.7% 41.3% 36.8%	0.0% 0.0% 0.0%	0.0% 0.0% 0.0%			

TABLE 25 Timber framed house design heat losses

Room	Design heat loss (W)	Design heat lossx1.2	Stelrad radiator				
			Output (W)	Heating surface area (m²)	Single/ double	Length (m)	Height (m)
Living	1828.8	2195	2169	4.660	double	1.76	0.59
Dining	1666.7	2000	1983	3.389	single	2.56	0.59
Kitchen	949.3	1139	1155	1.917	single	1.92	0.44
Hall and landing	928.7	1114	1116	1.906	single	1.44	0.59
B'room 1	934.6	1122	1120	1.784	single	2.56	0.30
B'room 2	723.1	868	868	1.483	single	1.12	0.59
B'room 3	521.5	626	630	1.003	single	1.44	0.30
Bathroom	606.0	727	722	1.583	double	0.48	0.74
W.C.	94.5	113	-	-	-	-	-

TABLE 26 Radiator sizes for detached house

Room	Design heat loss (W)	Design heat lossx1.2	Stelrad radiator				
			Output (W)	Heating surface area (m²)	Single/ double	Length (m)	Height (m)
Living	1304.2	1565	1577	3.389	double	1.28	0.59
Dining	1384.5	1661	1662	3.344	double	2.40	0.30
Kitchen	582.5	699	700	1.155	single	1.60	0.30
Hall and landing	850.9	1021	997	2.007	double	1.44	0.30
B'room 1	682.0	818	840	1.338	single	1.92	0.30
B'room 2	461.0	553	554	1.115	double	0.80	0.30
B'room 3	437.7	525	554	1.115	double	0.80	0.30
Bathroom	727.1	873	868	1.483	single	1.12	0.59

TABLE 27 Radiator sizes for semi-detached house

Room	Design heat loss (W)	Design heat lossx1.2	Stelrad radiator				
			Output (W)	Heating surface area (m²)	Single/ double	Length (m)	Height (m)
Living	1359.4	1631	1637	2.716	single	2.72	0.44
Dining	1363.0	1636	1637	2.716	single	2.72	0.44
Kitchen	594.2	713	722	1.583	double	0.48	0.74
Hall	201.4	242	280	0.446	single	0.64	0.30
B'room 1	1018.5	1222	1219	2.453	double	1.76	0.30
B'room 2	683.2	820	840	1.338	single	1.92	0.30
Bathroom	636.7	764	766	1.598	double	0.80	0.44

TABLE 28 Radiator sizes for bungalow

Room	Design heat loss (W)	Design heat lossx1.2	Stelrad radiator				
			Output (W)	Heating surface area (m²)	Single/ double	Length (m)	Height (m)
Living	1223.7	1468	1488	2.542	single	1.92	0.59
Dining	1302.2	1563	1551	3.121	double	2.24	0.30
Kitchen	485.8	583	578	0.959	single	0.96	0.44
Hall and landing	372.9	447	443	0.893	double	0.64	0.30
B'room 1	674.4	809	789	1.694	double	0.64	0.59
B'room 2	619.2	743	744	1.271	single	0.96	0.59
B'room 3	381.2	457	460	0.959	double	0.96	0.44
Bathroom	533.1	640	630	1.003	single	1.44	0.30

TABLE 29 Radiator sizes for post-1919 terrace, hall party

Room	Design heat loss (W)	Design heat lossx1.2	Stelrad radiator				
			Output (W)	Heating surface area (m²)	Single/ double	Length (m)	Height (m)
Living	907.5	1089	1073	2.237	double	1.12	0.44
Dining	1053.8	1265	1260	2.007	single	2.88	0.30
Kitchen	461.2	553	554	1.115	double	0.80	0.30
Hall and landing	344.8	414	420	0.669	single	0.96	0.30
B'room 1	470.7	565	560	0.892	single	1.28	0.30
B'room 2	370.8	445	443	0.893	double	0.64	0.30
B'room 3	381.2	457	460	0.959	double	0.96	0.44
Bathroom	533.1	640	630	1.003	single	1.44	0.30

TABLE 30 Radiator sizes for post-1919 terrace, mid

Room	Design heat loss (W)	Design heat lossx1.2	Stelrad radiator				
			Output (W)	Heating surface area (m²)	Single/ double	Length (m)	Height (m)
Living	959.4	1151	1155	1.917	single	1.92	0.44
Dining	1094.6	1314	1330	2.676	double	1.92	0.30
Kitchen	665.1	798	789	1.694	double	0.64	0.59
Hall and landing	495.7	595	591	1.271	double	0.48	0.59
B'room 1	470.7	565	560	0.892	single	1.28	0.30
B'room 2	370.8	445	443	0.893	double	0.64	0.30
B'room 3	517.7	621	620	1.059	single	0.80	0.59
Bathroom	705.7	847	840	1.338	single	1.92	0.30

TABLE 31 Radiator sizes for post-1919 terrace, living room party

Room	Design heat loss (W)	Design heat lossx1.2	Stelrad radiator					
			Output (W)	Heating surface area (m²)	Single/ double	Length (m)	Height (m)
Living	1747.7	2097	2107	3.601	single	2.72	0.59
Dining	1351.6	1622	1637	2.716	single	2.72	0.44
Kitchen	960.2	1152	1155	1.917	single	1.92	0.44
Hall and landing	285.3	342	332	0.669	double	0.48	0.30
B'room 1	1161.1	1393	1400	2.230	single	3.20	0.30
B'room 2	695.7	835	840	1.338	single	1.92	0.30
Bathroom	1124.8	1350	1348	2.237	single	2.24	0.44

TABLE 32 Radiator sizes for post-1919 terrace, hall party

Room	Design heat loss (W)	Design heat lossx1.2	Stelrad radiator				
			Output (W)	Heating surface area (m²)	Single/ double	Length (m)	Height (m)
Living	1323.1	1588	1577	3.389	double	1.28	0.59
Dining	949.7	1140	1155	1.917	single	1.92	0.44
Kitchen	960.2	1152	1155	1.917	single	1.92	0.44
Hall and landing	285.3	342	332	0.669	double	0.48	0.30
B'room 1	808.3	970	490 490	0.780 0.780	single single	1.12 1.12	0.30 0.30
B'room 2	361.9	434	443	0.893	double	0.64	0.30
Bathroom	1124.8	1350	1348	2.237	single	2.24	0.44

TABLE 33 Radiator sizes for period terrace, mid

Room	Design heat loss (W)	Design heat lossx1.2	Stelrad radiator				
			Output (W)	Heating surface area (m^2)	Single/ double	Length (m)	Height (m)
Living	1323.1	1588	1577	3.389	double	1.28	0.59
Dining	949.7	1140	1155	1.917	single	1.92	0.44
Kitchen	1265.7	1519	1533	2.196	double	1.60	0.44
Hall and landing	584.1	701	700	1.115	single	1.60	0.30
B'room 1	1161.1	1393	1400	2.230	single	3.20	0.30
B'room 2	361.9	434	443	0.893	double	0.64	0.30
Bathroom	1440.6	1729	1686	3.515	double	1.76	0.44

TABLE 34 Radiator sizes for period terrace, living room party

Room	Design heat loss (W)	Design heat lossx1.2	Stelrad radiator				
			Output (W)	Heating surface area (m^2)	Single/ double	Length (m)	Height (m)
Living & Dining	2129.4	2555	2563	5.507	double	2.08	0.59
Kitchen	584.0	701	700	1.115	single	1.60	0.30
Hall and landing	430.8	517	490	0.780	single	1.12	0.30
B'room 1	458.6	550	554	1.115	double	0.80	0.30
B'room 2	436.3	524	554	1.115	double	0.80	0.30
B'room 3	238.9	287	289	0.479	single	0.48	0.44
Bathroom	432.0	518	496	0.847	single	0.64	0.59

TABLE 35 Radiator sizes for timber-framed house, hall party

Room	Design heat loss (W)	Design heat lossx1.2	Stelrad radiator				
			Output (W)	Heating surface area (m²)	Single/ double	Length (m)	Height (m)
Living & Dining	1883.6	2260	2266	3.958	single	2.40	0.74
Kitchen	508.7	610	613	1.278	double	0.64	0.44
Hall and landing	406.0	487	481	0.799	single	0.80	0.44
B'room 1	365.2	438	443	0.893	single	0.64	0.30
B'room 2	354.5	425	420	0.669	single	0.96	0.30
B'room 3	238.9	287	289	0.479	single	0.48	0.44
Bathroom	432.0	518	496	0.847	single	0.64	0.59

TABLE 36 Radiator sizes for timber-framed house, mid

Room	Design heat loss (W)	Design heat lossx1.2	Stelrad radiator				
			Output (W)	Heating surface area (m²)	Single/ double	Length (m)	Height (m)
Living & Dining	2073.9	2489	2563	5.507	double	2.08	0.59
Kitchen	534.0	641	630	1.003	single	1.44	0.30
Hall and landing	583.2	700	700	1.115	single	1.60	0.30
B'room 1	365.2	438	443	0.893	double	0.64	0.30
B'room 2	354.5	425	420	0.669	single	0.96	0.30
B'room 3	298.4	358	350	0.557	single	0.80	0.30
Bathroom	481.4	578	578	0.959	single	0.96	0.44

TABLE 37 Radiator sizes for timber-framed house, kitchen party

7 INFILTRATION RATES

The infiltration rates used in the design heat loss calculations were those quoted in Section A4 of the CIBS guide (CIBS 1976). An idea of infiltration rates in practice is gained from Warren and Webb (1980), which presents the results of infiltration and air leakage measurements in a number of dwellings. Whole house and single room infiltration measurements were conducted, in unoccupied houses with windows closed, by monitoring the exponential decay of a tracer gas. Figure 22 overleaf presents the aggregated results of 430 measurements in 26 houses, showing a mean whole house infiltration rate of 0.7 ach (the median value is 0.6 ach and 1.3 ach is exceeded on only 10% of occasions). Table 38 below gives room infiltration rates at the mean wind speed for each particular site.

Room type	Number of rooms in the sample	Ventilation rates (ach)		
		Mean value	Range	
			Minimum	Maximum
Living room	16	0.89	0.24	1.64
Kitchen	17	1.43	0.43	3.50
Bathroom	18	1.81	0.25	3.19
Large bedroom (volume $>15m^3$)	29	0.65	0.25	1.19
Small bedroom (volume $<15m^3$)	14	0.87	0.28	2.90

TABLE 38 Room ventilation rate at mean wind speed for different types of room

It is suggested that, for the purpose of comparing results from more than one model or more than one modeller, the mean values given in the above table should be used in building simulations, in preference to those used to calculate design heat losses. However, it is recognised that, in practice, house occupiers will open and close windows in response to prevailing conditions, and therefore higher values are likely to be a better approximation to reality.

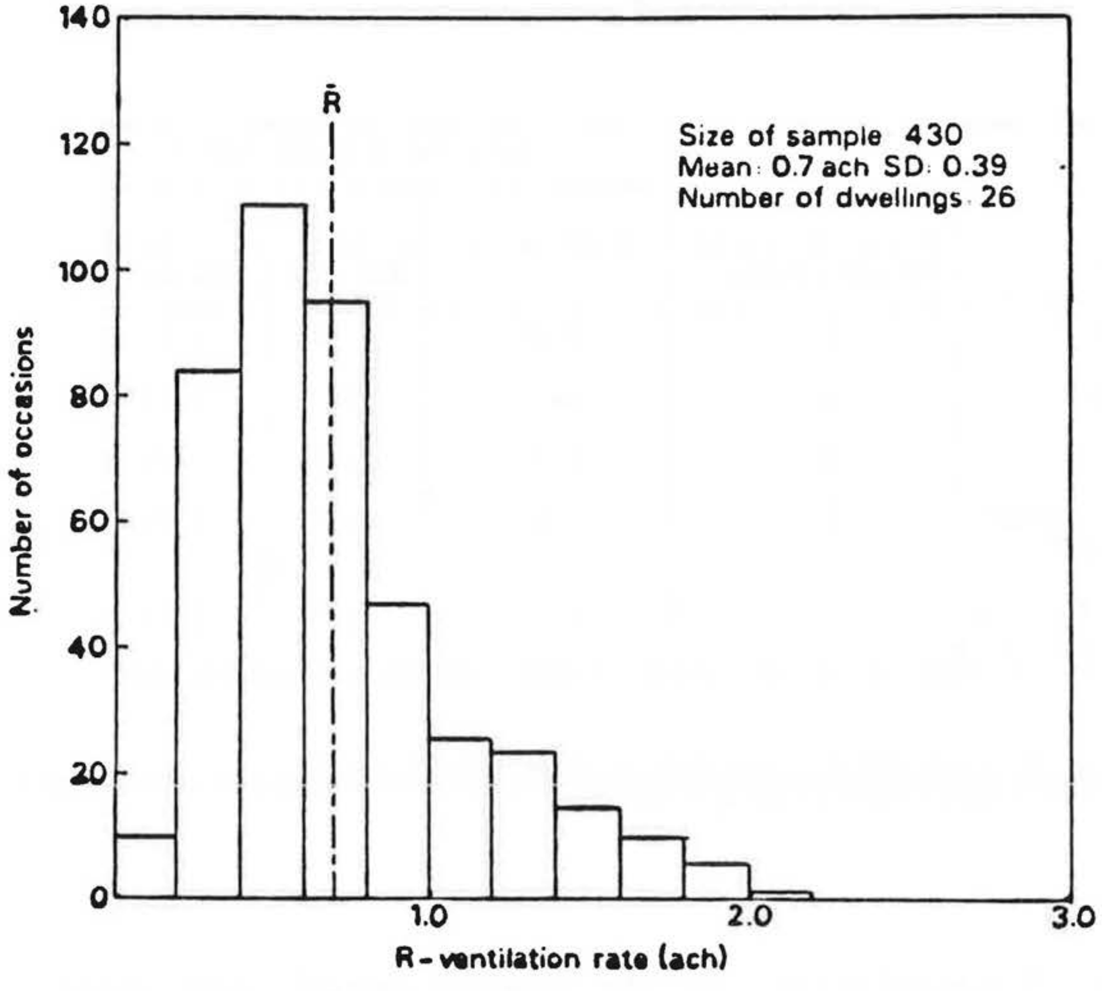


FIGURE 22 Distribution of whole-house ventilation rates

8 OCCUPANCY SCHEDULES AND CASUAL GAINS

In order to determine accurately the heating or cooling loads of a building it is necessary to take account of the incidental heat gains from occupants and casual gains from appliances, cooking, hot water. etc. Two occupancy profiles, corresponding to 'heavy' occupancy (a couple with two young children less than 5 years old, with wife not working) and 'light' occupancy (a couple with two children of school age with husband and wife working full-time) are presented. These are based on previous work at BRE (Rayment et al 1980), except that gains have been rounded to the nearest whole hour (the total gain remaining the same).

The magnitudes and times of occurrence of incidental heat gains owing to occupants, cooking, lighting and other electrical appliances are given for each room in the house. The figures for light and heavy occupancy are shown in tables 41 and 42 respectively. These are presented as hourly values, in line with the requirements of most current thermal models. The total daily incidental heat gains for each profile are shown in table 39 below, for a three-bedroom house. For two-bedroom houses the gains from bedroom 3 are not used.

The way in which casual gains are split into latent and sensible heat, and convective and radiative proportions, are shown in table 40.

Heat source	Total Heat Gain kWh/day	
	'Heavy' profile	'Light' profile
Occupants	5.46	4.02
Lights	2.50	2.17
Cooker	4.25	2.89
Refrigerator	1.44	1.44
Television	0.54	0.45
Hot water	4.70	3.70

TABLE 39 Total daily incidental heat gains

Heat source	Latent (%)	Sensible (%)	Convective (%)	Radiative (%)
Occupants	40	60	80	20
Lights	0	100	20	80
Television	0	100	80	20
Cooker	10	90	60	40
Refrigerator	0	100	80	20
Hot water	40	60	80	20

TABLE 40 Latent and sensible, and convective and radiative splits of casual gains sources

Room type	Casual Gain Source: Occupants Time*	Gain (W)	Lights Time	Gain (W)	T.V. Time	Gain (W)	Cooker Time	Gain (W)	Fridge Time	Gain (W)	H. Water Time	Gain (W)
Living	17.0 -23.0	144	17.0 -23.0	212	17.0 -18.0 20.0 -22.0	135 158						
Dining	08.0 -09.0 18.0 -20.0	140 115	08.0 -09.0 18.0 -20.0	126 171								
Kitchen	07.0 -08.0 18.0 -21.0	84 84	07.0 -08.0 18.0 -21.0	56 56			07.0 -08.0 18.0 -19.0	1190 1700	00.0 -24.0	60	00.0 -24.0	77
Bedroom 1	00.0 -08.0 23.0 -24.0	148 148										
Bedroom 2	00.0 -09.0 21.0 -24.0	38 38										
Bedroom 3	00.0 -09.0 21.0 -24.0	38 38										
Bathroom	07.0 -08.0 17.0 -18.0 21.0 -23.0	100 40 35	07.0 -08.0 17.0 -18.0 21.0 -23.0	100 40 35							00.0 -24.0	77

Notes: * = Hour values are as follows: there are 24 hours per day, hour 1 being 00.0-01.0, etc. Therefore 18.0-20.0 above (for example) means 18.0-19.0 (hour 19) and 19.0-20.0 (hour 20).
During the heating season, heating is 'on' between 07.0-09.0 and 16.0-23.0.
Curtains are closed between 17.0 and 08.0.

TABLE 41 Casual gains from 'light' occupancy

Room type	Casual Gain Source					
	Occupants Time* Gain (W)	Lights Time Gain (W)	T.V. Time Gain (W)	Cooker Time Gain (W)	Fridge Time Gain (W)	H. Water Time Gain (W)
Living	09.0 -23.0 125	17.0 -23.0 248	17.0 -18.0 160 20.0 -23.0 125			
Dining	08.0 -09.0 100 17.0 -19.0 115	08.0 -09.0 90 17.0 -19.0 171				
Kitchen	08.0 -09.0 120 12.0 -14.0 108 17.0 -20.0 88	08.0 -09.0 80 12.0 -14.0 72 17.0 -20.0 59		07.0 -08.0 680 12.0 -13.0 1190 17.0 -18.0 2380	00.0 -24.0 60	0.00 -24.0 98
Bedroom 1	00.0 -08.0 147 10.0 -11.0 45 23.0 -24.0 147					
Bedroom 2	00.0 -08.0 41 09.0 -10.0 70 19.0 -20.0 56 20.0 -24.0 41					
Bedroom 3	00.0 -08.0 41 09.0 -10.0 70 19.0 -20.0 56 20.0 -24.0 41					
Bathroom	07.0 -08.0 80 10.0 -11.0 20 17.0 -18.0 40 19.0 -20.0 40	07.0 -08.0 80 10.0 -11.0 20 17.0 -18.0 40 19.0 -20.0 40				00.0 -24.0 98

Notes: * = As table 41.
During the heating season, heating is 'on' between 07.0-23.0.

TABLE 42 Casual gains from 'heavy' occupancy

9 THE NEED FOR FUTHER WORK

The building descriptions presented in this report should provide the user with all the information needed to simulate them using most of the current thermal models. However, in order for them to be useful, a set of benchmark results should be established, against which any new model could be tested. These results would have to be in the form of inter-model comparisons, since no measured data are available for the buildings presented here. It is suggested, therefore, that a range of current models (not only detailed ones) be used to produce benchmark results using pre-defined weather data, and with the building specification, occupancy levels and heating regime rigorously defined. Useful results could be annual and monthly energy consumption and daily maximum, minimum and mean internal air temperatures during a typically hot and a typically cold day.

As mentioned in the report, the set of house types presented here does not fully cover that range of all typical UK house types or constructions. To extend the set, it would be worth including, in particular, flats, three storey 'town houses', one and four bedroom dwellings, detached houses with larger floor areas, and houses with integral garages. To extend the construction types, it may be worth adding more examples of solid walls and more examples of suspended floors. It is hoped that work currently underway by members of the BEPAC Standardisation Task Group, will provide the data necessary to extend the current set.

10 ACKNOWLEDGEMENTS

This work is part of the research program of the Building Research Establishment of the U.K. Department of the Environment, and this report is published by permission of the Director.

11 REFERENCES

BLOOMFIELD, D.P. 1984 Thermal Design of Buildings. BRE micro-computer package, Building Research Establishment, Watford.

CLARKE, J.A. 1984 The Program ESPWIN. ESP Users Manual, ABACUS Unit, Dept. of Architecture, University of Strathclyde, Glasgow.

CIBS 1976 CIBS Guide (1976) Section A4 - Air Infiltration. The Chartered Institution of Building Services Engineers, London.

CIBS 1977 CIBS Guide (1977) Section A7 - Casual Gains. The Chartered Institution of Building Services Engineers, London.

CIBS 1978 CIBS Guide (1978) Section A1 - Environmental Criteria for Design. The Chartered Institution of Building Services Engineers, London.

CIBS 1979 CIBS Guide (1979) Section A6 - Solar Data. The Chartered Institution of Building Services Engineers, London.

CIBS 1980 CIBS Guide (1980) Section A3 - Thermal Properties of Building Structures. The Chartered Institution of Building Services Engineers, London.

LEACH, G. 1981 Energy Related Statistics for U.K. Dwellings. International Institute for Environment and Development, London.

RAYMENT, R,. CUNLIFFE, A.R. & MORGAN, K. 1980 Basic Characteristics of Low-Cost Houses in Order to Reduce the Energy Consumption for Heating - Efficiency of Heating Plants and Controls. CEC Report no. EUR 8506 EN, DG XII, Commission of the European Communities, Brussels.

WARREN, P.R. & WEBB, B.C. 1980 Ventilation Measurements in Housing. Proc. CIBS Conference 'Natural Ventilation by Design', BRE Watford, 2nd Dec. 1980.